S-080-2007
(Consultant)

MEMORANDUM

TO: Allan Frank, P.E.
Division of Bridge Design

FROM: William Broyles, P.E.
Geotechnical Branch Manager

BY: Bart Asher, P.E., P.L.S.
Geotechnical Branch

DATE: February 1, 2007

SUBJECT: **Jefferson County**
1200 056
Mars # 6554101D
Muhammad Ali Boulevard to I-65 Northbound CD
S0620 (BA-1)
Ohio River Bridges Project
Kennedy Interchange – Section 1
Item No. 5-118.18 & .19

The geotechnical engineering report for this structure has been completed by Fuller, Mossbarger, Scott & May Engineers. We have reviewed and concur with the recommendations as presented in this report.

A copy of the report is attached. If you have any questions, please contact this office at 502-564-2374.

Attachment:

cc: J. Callihan
R. Harris
N. Stroop
A. Calvin
B. Greene
B. Bryant

Glen Kelly	(KTA-QK4)	(w/o attachment)
Patrick Kiser	(FMSM)	(w/o attachment)
Donald Blanton	(FMSM)	(w/o attachment)

Report of Geotechnical Exploration

Muhammad Ali Boulevard to I-65
Northbound CD
S0620 (BA-1)
Ohio River Bridges Project
Kennedy Interchange - Section 1
Item Nos. 5-118.18 & 19
Jefferson County, Kentucky

Prepared for:
KTA - Qk4
Louisville, Kentucky

January 8, 2007

FULLER, MOSSBARGER, SCOTT & MAY ENGINEERS, INC.

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Fuller Mossbarger Scott & May
FMSM
ENGINEERS

January 8, 2007

O.1.1.LX2004130-S0620R01

KTA - Qk4
815 West Market Street, Suite 300
Louisville, Kentucky 40202

Re: Report of Geotechnical Exploration
Muhammad Ali Boulevard to I-65 Northbound CD
S0620 (BA-1)
Ohio River Bridges Project
Kennedy Interchange - Section 1
Item Nos. 5-118.18 & 19
Jefferson County, Kentucky

Dear Mr. Kelly:

Fuller, Mossbarger, Scott and May Engineers, Inc. (FMSM) is submitting the geotechnical engineering report for the referenced structure with this letter. The exploration performed for the subject bridge structure generally followed the guidelines presented in the Kentucky Transportation Cabinet's Geotechnical Manual and the Final Boring Plan dated February 28, 2006. The KYTC Geotechnical Branch reviewed and approved the boring plan on February 27, 2006. This report also addresses comments offered by the Branch subsequent to their review of a draft copy of this report.

This report presents results of the field exploration along with our recommendations for the design and construction of the substructure elements proposed for the referenced bridge. As always, we enjoy working with your staff and if we can be of further assistance, please contact our office.

Sincerely,

FULLER, MOSSBARGER, SCOTT AND MAY
ENGINEERS, INC.

Patrick V. Kiser

Patrick V. Kiser, PE
Senior Project Engineer

Donald Blanton

Donald L. Blanton, PE
Project Manager

/rdr

cc: Mr. Bill Broyles, PE (KYTC) 3 bound copies and electronic files
ProjectWise

Report of Geotechnical Exploration

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Appendix

Report of Geotechnical Exploration

Muhammad Ali Boulevard to I-65 Northbound CD
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Ohio River Bridges Project
Kennedy Interchange - Section 1
Item Nos. 5-118.18 & 19
Jefferson County, Kentucky

1. Introduction

1.1. Project Overview

The Bi-State Management Team, consisting of representatives from the Federal Highway Administration (FHWA), Kentucky Transportation Cabinet (KYTC) and Indiana Department of Transportation (INDOT), is planning and overseeing the design of the Ohio River Bridges Project, which will address the cross-river transportation needs in Louisville, Kentucky and Southern Indiana. The Ohio River Bridges Project consists of six (6) separate design sections.

- Section 1 - Kennedy Interchange
- Section 2 - Downtown Bridge
- Section 3 - Downtown Indiana Approach
- Section 4 - East End Kentucky Approach
- Section 5 - East End Bridge
- Section 6 - East End Indiana Approach

As a part of the Ohio River Bridges Project, the Kennedy Interchange will be reconstructed/relocated just south of its current location. The relocation includes the widening, reconstruction and construction of over 80 bridges, construction of approximately 28 retaining walls and about 22 miles of roadway, ramps and connectors to allow for more efficient traffic movement. Kentucky Transportation Associates (KTA), a collaboration of several engineering consulting firms, is serving as the design consultant for the Kennedy Interchange reconstruction/relocation.

1.2. Structure Location and Description

Reconstruction of the Kennedy Interchange section of the Ohio River Bridges project includes the widening of Interstate 65 (I-65) to accommodate additional lanes of travel and new entrance/exit ramps. This report specifically addresses the geotechnical concerns relative to the new construction of the I-65 bridge connecting Muhammad Ali Boulevard to I-65 Northbound CD, designated as S0620 (BA-1). Project plans provided to Fuller, Mossbarger, Scott and May Engineers, Inc. (FMSM) by KTA ? WMB (WMB) indicate the bridge will begin at approximate Ramp 3 Station 32+87 and end at Station 41+57. The centerline of the planned substructure element will intersect the Ramp 3 alignment as indicated in Table 1.

Table 1. Stationing of Bridge Substructure Elements

Element	Ramp 3 Station
Abutment 1	32+87.5
Pier 1	34+33.2
Pier 2	35+86.5
Pier 3	37+19.8
Pier 4	38+60.1
Pier 5	39+89.2
Abutment 2	41+56.7

Structure plans indicate the construction will consist of a new six span bridge carrying Ramp 3 over Liberty Street, Preston Street and Jefferson Street. The location map provided in Appendix A illustrates the relative location of the bridge site in relation to the planned project alignments and associated structures as well as the existing city streets and current interstate alignment. Appendix B presents structure drawings for the referenced bridge downloaded from the KTA ProjectWise website on Monday, June 5, 2006. The recommendations provided in this report are based on the bridge configuration presented in these drawings.

2. Site Topography and Geologic Conditions

The project is located in the northwestern portion of Central Kentucky within the Outer Bluegrass Physiographic Region. The topography within the Outer Bluegrass varies from rolling hills to relatively flat, low-lying areas adjacent to major drainage features. The bridge site is located in downtown Louisville, approximately ¾-mile south of the Ohio River. As such, the Ohio River will influence groundwater levels at the proposed structure site. Topography within the vicinity of the bridge is relatively flat, with local relief generally less than five feet. However, highway embankments dissect the area and can rise as much as 35 feet above the surrounding terrain.

Available geologic mapping (Geologic Map of Parts of the Jeffersonville, New Albany, and Charlestown Quadrangles, Kentucky-Indiana, USGS, 1974) shows the project alignment to be underlain by Outwash deposits of the Pleistocene geologic period. The mapping describes the Outwash as varying in thickness up to approximately 130 feet and consisting of sand, gravel, silt and clay deposited as alluvium by low-gradient rivers formed by glacial melt waters.

The geologic mapping does not depict structural contours within the immediate vicinity of the project alignment because of insufficient data. However, structural contours drawn on the top of the Waldron Shale in the Jeffersonville Quadrangle and the base of the New Albany Shale in the New Albany Quadrangle indicate the bedrock is relatively flat. The mapping shows the Springdale Anticline to be located approximately 3.8 miles southeast of the project, but does not note any faults or other detrimental geologic features to be present within the immediate vicinity of the bridge site.

3. Summary of Borings

FMSM developed a boring plan for the proposed structure after a review of available bridge plans and profiles provided by KTA. The subsurface exploration consisted of completing six (6) sample borings, designated herein as Hole Nos. 1B-16, 1B-17, 1B-20, 1B-21, 1B-22 and 1B-23. Upon encountering bedrock in Hole 1B-16, rock coring was performed. Engineering and laboratory testing related to boring 1B-22 are being performed by others.

KTA ? Qk4 survey personnel established the boring locations and surface elevations in accordance with the Final Boring Plan dated February 28, 2006. Table 2 provides a summary of the stations, offsets, elevations, and depths of the borings drilled for the subject bridge structure. The boring locations are referenced to I-65 mainline stationing.

Table 2. Summary of Borings

Hole No.	Station/ Offset*	Surface Elevation	Top of Rock Elevation	Refusal/ Begin Core Elevation	Length of Core	Boring Termination Depth	Bottom of Hole Elevation
1B-16	646+66, 263′ Rt.	455.3	336.5	336.5	20.0	138.8	316.5
1B-17	648+30, 198′ Rt.	460.6	--	--	--	80.0	380.6
1B-23	650+92, 94′ Rt.	460.9	--	--	--	80.0	380.9
1B-20	653+00, 92′ Rt.	462.9	--	--	--	80.0	382.9
1B-21	655+26, 103′ Rt.	462.0	--	--	--	100.0	362.0
1B-22	649+13, 81′ Rt.	459.8	--	--	--	80.0	379.8

* Station and Offset based on I-65 Centerline

FMSM personnel performed drilling and sampling operations in March, April, and May 2006. A geotechnical engineer from FMSM monitored the field operations and adjusted the boring program as field and/or subsurface conditions warranted. The drill crews operated one ally-terrain-vehicle mounted drill rig and one truck-mounted drill rig equipped with hollow-stem augers. The field personnel generally performed soil sampling at five-foot intervals of depth to provide in situ strength data and specimens for subsequent laboratory strength and/or classification testing. Typically, undisturbed thin-wall (Shelby) tube samples were obtained within cohesive soil horizons and standard penetration (SP) testing was performed within granular (non-cohesive) materials. The drill crews checked each boring for the presence of groundwater prior to backfilling. The Subsurface Data Sheets in Appendix C provide a boring layout that depicts the locations of the borings in relation to the planned structure as well as graphical logs presenting the results of the drilling, sampling, and laboratory testing programs. Refer to Appendix D for the Coordinate Data Submission Form summarizing the as-drilled boring locations, surface elevations, and associated latitudes and longitudes.

The drill rigs utilized for the sampling operations were equipped with automatic hammers to perform SP testing in accordance with Section 302-5 of the current KIT Geotechnical Manual. The use of automatic hammers provides for a more efficient and consistent transfer of energy than traditional SP testing with a safety hammer/rope/cat-head system. Thus, blow counts observed from automatic hammers are lower than those observed with the safety hammer system. Typical correlations for SP results used in geotechnical engineering are based on the safety hammer system and require that blowcounts from SP testing using an automatic hammer be corrected for efficiency. A discussion on the correction of the blowcounts is included in Section 6 of this report. The corrected N-values will be utilized in subsequent sections of this report for applicable engineering analyses.

4. Soil, Bedrock, and Groundwater Conditions

The drilling and sampling operations performed for the planned bridge construction indicate the subsurface materials consist of relatively thick (120+ feet) soil deposits consistent with the outwash/alluvial type materials described by the geologic mapping. In general, the subsurface materials observed during drilling operations primarily consist of a relatively thin mantle of clay (10 to 15 feet thick) overlying sand deposits extending to bedrock. Drilling operations suggest the top of bedrock is approximately 120 feet below the ground surface.

Surface materials overlying the outwash deposits consist of topsoil, concrete, and/or fill materials associated with previous development in the city of Louisville. Hole 1B-16, 1B-17, 1B-20, 1B-21, 1B-22 and 1B-23 were drilled at the proposed substructure elements and encountered both topsoil and fill materials extending to depths of approximately 0.2 feet and 8.5 feet, respectively. Generally, the zone described as topsoil consisted of an organic dark brown soil mantle containing grass roots. The engineer monitoring the drilling operations described the fill materials as consisting of silty to sandy lean clay mixed with brick fragments and remnants. Drilling operations encountered concrete underlain by a layer of crushed stone within Hole 1B-22 because the boring was located within the limits of a city sidewalk.

The outwash deposits encountered within the test borings generally consisted of approximately 10 feet of sandy lean clay overlying relatively thick sand deposits (100+ feet) with varying amounts of gravel and silt. The field engineer visually described the clay soils as being brown to dark brown in color, damp to moist in terms of natural moisture content, medium stiff to stiff in consistency, and containing varying amounts of sand and gravel. The natural moisture content of the clay materials generally increased with increasing depth.

The sands observed in the borings are brown to gray in color, fine- to medium-grained, damp to wet in terms of natural moisture content, loose to dense, and contain varying amounts of gravel size particles. Uncorrected N-values from SP testing ranged from a low of 0 to a high of 61 blows per foot. In general, the upper 22 to 27 feet of the sand deposits from the proposed centerline of Pier 2 to the back-station abutment of the proposed bridge exhibit low N-values (10 or less), with an average uncorrected N-value of about 9. The lower sands grade into more dense sands and gravels with N-values ranging from a minimum of 5 to a maximum of 61 blows per foot (average uncorrected N-value of about 28).

The drill crews performed rock coring operations in Hole 1B-16 to obtain twenty (20) feet of rock core. A geotechnical engineer logged the core during drilling operations. The bedrock obtained from coring operations consists of limestone described as being gray in color, micro- to fine-crystalline-grained, thin- to medium-bedded, and containing shale streaks, stringers, and partings. The engineer also determined the base of weathered rock, percent recovery, and standard rock quality designation (RQD) for each core run. The RQD is defined as the sum of all core pieces longer than 4 inches, divided by the total length of the coring run. The KYTC modifies the RQD by excluding from the sum those portions of core that can be broken by hand pressure. The resultant is multiplied by 100 to express the RQD in percent. The RQD provides a simple quantitative indication of rock competency. The

RQD values measured for the rock samples obtained from coring operations vary from 90 to 96 percent. Intact rock core specimens indicate the base of weathered rock is located at or near the top of rock.

FMSM personnel recorded an approximate measurement of the depth to the groundwater surface at each boring during drilling and sampling operations. Based on the groundwater level observations prior to backfilling the borings, the groundwater level at the structure site varies from approximate elevation 418.2 at the location of Hole 1B-16 to 424.0 at Hole 1B-20. The average elevation derived from the observations is 421.0 feet, which correlates well with the normal pool elevation of 420 feet for the Ohio River noted on the geologic mapping. The graphical logs provided on the Subsurface Data Sheets in Appendix C depict the approximate location of the groundwater surface, as recorded in each boring.

5. Laboratory Testing and Results

5.1. General

Selected soil specimens recovered during standard penetration testing and Shelby tube sampling operations were subjected to natural moisture content, wash gradation (silt plus clay determinations), soil classification, unconfined compressive strength, and unconsolidated-undrained triaxial testing. FMSM performed laboratory testing in accordance with applicable American Association of State Highway Transportation Officials (AASHTO) or Kentucky Methods (KM) of soil testing specifications. FMSM performed the laboratory testing for samples obtained from Hole Nos. 1B-16, 1B-17, 1B-20, 1B-21 and 1B-23. K.S. Ware Associates, L.L.C. is providing geotechnical engineering services for S0750 (B65-5) and performed the laboratory testing for samples associated with 1B-22. Laboratory personnel developed the soil classification identifications in accordance with both the Unified (USCS) and AASHTO soil classification systems. The test results were used to establish material properties for subsequent engineering analyses to estimate soil bearing capacities and settlements of proposed foundation elements as well as evaluate slope stability of the bridge approach embankments. The following paragraphs provide detailed discussions of the laboratory testing program.

5.2. Testing of Cohesive Soils/Undisturbed (Shelby) Tube Samples

Borings drilled for the subject bridge construction included undisturbed (Shelby) tube sampling within predominantly cohesive soil horizons. FMSM's soils laboratory extruded the tubes and trimmed six-inch specimens. Lab personnel determined visual descriptions, unit weights (wet and dry), and natural moisture for each six-inch specimen prior to submitting a summary of the extruded specimens to a geotechnical engineer for assignment of lab testing. The laboratory testing performed on the extruded samples consisted of engineering classification and unconfined compressive strength testing. The following paragraphs provide further discussion of the test results.

5.2.1. Engineering Classification Test Results for Cohesive Samples

FMSM performed engineering classification testing on selected six-inch Shelby tube specimens. The testing included one classification test per soil type in a Shelby tube. The cohesive soils classify as CL and CL-ML according to USCS, and A-6 and A-4 based on the AASHTO classification system. Classification testing performed on Shelby tube samples obtained within the upper seven feet of the borings classify as SM/A-2-4 and appear to be representative of fill materials. Testing of the Shelby tube samples encountering the top of the sand deposits resulted in classifications of SM based on USCS and A-2-4 based on the AASHTO classification system. The Subsurface Data Sheets provided in Appendix C depict the results of the classification testing adjacent to the graphical logs.

5.2.2. Unconfined Compressive Strength Testing of Cohesive Samples

FMSM performed unconfined compressive strength testing on soil specimens to provide information for estimating total stress strength parameters for the cohesive soil horizon. The unconfined compressive strength values obtained range from 1,160 psf (0.58 tsf) to 1,260 psf (0.63 tsf). Table 3 summarizes the data obtained from this testing. The Subsurface Data Sheets provided in Appendix C also depict the results of the unconfined compressive strength testing adjacent to the appropriate graphical log.

Table 3. Summary of Unconfined Compressive Strength Tests

Hole No.	Station and Offset	Sample Interval (ft)	Unit Weight		Moisture Content %	Unconfined Compressive Strength (psf)	Estimated Cohesion (psf)
			Dry (pcf)	Wet (pcf)			
1B-17	648+30, 198′ Rt.	2.0 - 2.5	100.9	123.3	22.3	1,160	580
1B-23	650+92, 94′ Rt.	15.5 - 16.0	106.9	128.8	20.5	1,260	630

The unconfined compressive strength can be used to estimate the bearing capacity and cohesion of a soil material. The value of cohesion in an engineering analysis is generally estimated to be one-half of the unconfined compressive strength for cohesive soils. Based on the above test results, the cohesion values derived from unconfined compression testing are 580 psf (0.29 tsf) and 630 psf (0.32 tsf).

5.3. Laboratory Testing of Non-Cohesive Soils/Standard Penetration Test Samples

Laboratory testing of the SP samples included natural moisture content, silt plus clay, and standard engineering classification testing. A geotechnical engineer selected SP samples to combine for engineering classification testing. The non-cohesive soils tested primarily classify as SW-SM with lesser occurrences of SP-SM, SM, SW, and SP according to USCS, and primarily as A-1-b with lesser occurrences of A-2-4, A-3, A-4 and A-1-a based on the AASHTO classification system. Refer to Table 4 for a summary of the classification testing performed on non-cohesive soil samples recovered from SP testing.

Table 4. Summary of Non-Cohesive Soil Classification Testing

USCS		AASHTO	
Soil Type	Percentage	Soil Type	Percentage
SW-SM	45	A-1-b	67
SP-SM	26	A-1-a	18
SM	15	A-2-4	7
SW	7	A-3	4
SP	7	A-4	4

The engineer used the results of the classification testing in conjunction with the N-values from SP testing to estimate soil strength and settlement parameters based on published correlations of such data.

6. Derivation of Soil Parameters

6.1. Correction of Standard Penetration Test Data

As discussed in Section 3 of this report, FMSM utilized drill rigs equipped with automatic hammers to perform SP testing. Standard correlations for SP testing consider blowcounts using a safety hammer/rope/cat-head system, generally estimated to be 60 percent efficient. Thus, correlations are based upon what is currently termed as N_{60} data. The efficiency of the automatic hammers used for this exploration was estimated to be approximately 80 percent based on previous efficiency testing of FMSM drill rigs equipped with automatic hammers. The correction for hammer efficiency is a direct ratio of relative efficiencies as follows:

$$N_{60} = N_{80}\left(\frac{80}{60}\right) \tag{6.1}$$

FMSM corrected standardized N_{60} values for the effect of overburden pressure prior to using the data in conjunction with correlations for non-cohesive soil parameters. N_{60} values were normalized to vertical effective overburden stresses of 2,000 pounds per-square foot. This calculation requires an effective unit weight for each soil horizon multiplied by the depth of the soil horizon. Liao and Whitman, as referenced in Seed and Harder [1990], proposed a relationship between the correction factor, C_N, and the effective overburden stress, σ':

$$C_N = \frac{1}{\sqrt{\sigma'}} \tag{6.2}$$

where:

C_N = correction factor for overburden stress

σ' = vertical effective overburden stress (tsf)

Consequently, the standardized corrected N-value, $(N')_{60}$ is equal to:

$$(N')_{60} = C_N N_{60} \tag{6.3}$$

where:

C_N = correction factor for overburden stress

N_{60} = standardized N-value

Appendix E contains summaries of the SP data and corrections for the six borings performed along the bridge alignment. The spreadsheets also include correlations of corrected SP data with published correlations for estimates of unit weight and shear strength parameters. The values of $(N')_{60}$ were utilized to obtain relative densities, D_r, based on relationships developed by Tokimatsu and Seed [1988]. NAVFAC [1982] presents a relationship using relative density of specific soil types to correlate angle of internal friction, unit weight and void ratio. Soil classifications for the correlations came from actual laboratory test results and visual observations, and were used to estimate an in situ unit weight of the material. Once the relationships for the angle of internal friction, unit weight and void ratio were established, an in situ unit weight was calculated based upon the natural moisture content.

6.2. Soil Parameter Selections

FMSM derived subsurface characterizations for the foundation soils along the bridge alignment based upon the results of the drilling and sampling program discussed in Sections 3 and 4 of this report, and the laboratory testing addressed in Section 5. The division of soil horizons was based on visual soil descriptions, laboratory classification data, and corrected SP data associated with Boring Nos. 1B-16, 1B-17, 1B-20, 1B-21 and 1B-23. Subsurface Data Sheet 4 of 4 in Appendix C presents the subsurface profile and summaries of estimated soil parameters modeled in engineering analyses.

A geotechnical engineer derived estimated soil parameters for each soil horizon. Strength and settlement parameters for the cohesive materials were estimated based on the results of laboratory classification, unconfined compressive, unconsolidated-undrained triaxial, and one-dimensional consolidation testing. Laboratory test results were used from nearby borings from adjacent structures when necessary. The parameters derived for the cohesive materials are representative of sandy lean clay soils and are typical of clay soils found in this region of the state. Likewise, the settlement and strength parameters for the non-cohesive materials (sand deposits) were estimated based on corrected SP data, laboratory classification testing, and correlations of such data. Values of internal angles of friction (ϕ') for granular soils obtained from the correlations vary from 29.5 to 39.0 degrees. A review of these parameters indicate in general an increasing trend with depth which coincides with dense coarse grained deposits typically found within the site′s geological setting.

7. Foundation Analyses

7.1. General

It is our understanding that the planned bridge construction will be supported by deep foundation elements. This project will be designed using the Load and Resistance Factor Design (LRFD) methodology. LRFD is a design approach in which applicable failure and serviceability conditions can be evaluated considering the uncertainties associated with loads and materials resistances. Where applicable, the following engineering analyses, in general, followed the current AASHTO LRFD guidelines. This report provides recommendations for both driven steel H-pile and drilled concrete shaft foundation options for support of the subject bridge structure.

7.2. Steel H-Pile Analyses

7.2.1. Pile Capacity

Based on information provided by the Designer, deep foundation elements bearing in the sand horizons overlying bedrock will be required and will rely primarily on friction resistance for axial capacity. A geotechnical engineer performed axial capacity estimates for three different H-pile sizes (12x53, 14x73 and 14x89). FMSM utilized the procedures outlined in the Federal Highway Administration Publication No. FHWA-HI-97-013, "Design and Construction of Driven Pile Foundations", and the computer program DRIVEN version 1.2, developed by Blue-Six Software, Inc. in conjunction with the FHWA, to estimate axial capacities of driven piles. The axial capacity calculations utilize soil parameters derived from the results of the field explorations and published correlations relating SP N-values to shear strengths. Appendix F provides Idealized Soil Profiles that outline the recommended soil parameters for use in lateral load analyses. Refer to Appendices G and H for single shaft/pile nominal axial capacity estimates determined for the abutment and pier locations, respectively.

Load and Resistance Factor Design (LRFD) incorporates the use of load factors and resistance factors to account for uncertainty in applied loads and load resistance of structure elements separately in contrast to the Factor of Safety traditionally applied only to the resistances in Allowable Stress Design (ASD) methodology. Selection of the resistance factors account for the type of loading (axial compression versus uplift) and the variability and reliability of models or methodologies used to determine nominal resistance (R_n) capacities. As mentioned previously, FMSM used the DRIVEN 1.2 computer program to perform the load capacity calculations for the subject bridge. Table 5 summarizes the applicable analysis methodologies utilized in the DRIVEN software as well as the resistance factors recommended by the AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 interim revisions).

Table 5. LRFD Resistance Factors for Driven Pile Capacity

Loading Condition	Resistance Mechanism	Analysis* Methodology	Resistance Factor** (**φ**)
Nominal Resistance of Single Pile in Axial Compression ? Static Analysis	Skin Friction and End Bearing ? Clay and Mixed Soils	α-Method	0.35
	Skin Friction and End Bearing ? Sand	Nordlund/Thurman Method	0.45
Uplift Resistance of Single Piles - Static Analysis	Side Resistance in Clay	α-Method	0.25
	Side Resistance in Sand	Nordlund Method	0.35

* The Designer should refer to this table for the applicable analysis methodology when determining the appropriate load factor for downdrag loads.

** From AASHTO LRFD Bridge Design Specifications, Third Edition (including 2005 and 2006 Interim Revisions), portion of Table 10.5.5.2.3-1

Table 6 summarizes the estimated depths below the anticipated pile cap at which the proposed H-piles could extend to achieve the maximum total factored geotechnical axial resistance (TFGAR) based on static analysis and the resistance factors for driven piles presented in Table 5, above. The KYTC Geotechnical Branch recommends that the maximum TFGAR for each pile size be limited to the values presented in Table 6. In accordance with Section 10.7.3.7 of the AASHTO LRFD Bridge Specifications, the pile lengths outlined in Table 6 were estimated by considering only the positive side friction and end bearing resistance below the zone contributing to downdrag.

Table 6. Summary of Driven Pile Capacities

Maximum Total Factored Geotechnical Axial Resistance[a]/Element (tons)	Depth[b] (ft)	Elevation[c] (ft)	Total Factored Geotechnical Uplift Resistance[d] (tons)
12x53 H-pile			
100/ Abutments 1 and 2	74.0	383.2	101.6
100/Piers 1 to 5	62.0	395.2	76.3
14x73 H-pile			
140/Abutments 1 and 2	75.5	381.7	141.6
140/Piers 1 to 5	63.5	393.7	106.8
14x89 H-pile			
170/Abutments 1 and 2	80.0	377.2	171.0
170/Piers 1 to 5	67.5	389.7	129.9

[a] Excludes any positive resistance within downdrag zone for Abutments 1 and 2.
[b] Depth as measured from the bottom of the pile cap.
[c] Based upon estimated bottom of pile cap at elevation 457.2 feet.
[d] Reported uplift resistance is for the corresponding pile length.

The Designer should note that these estimates are for the maximum TFGAR listed above. Should more or less capacity be required for each pile at the pier locations, refer to the pile/shaft capacity tables presented in Appendix H because the piers are not affected by downdrag. However, the pile capacity tables presented in Appendix G for the abutments are valid for the specified TFGAR only. The length estimates at the abutment locations are based on the pile capacities presented in Table 6 and the length of pile subjected to downdrag. Should more or less capacity be required, the Designer should consult FMSM because the downdrag load and length of pile subjected to downdrag are a function of the pile length. Additionally, should the elevation of the bottom of the pile cap change, pile lengths and elevations presented in Table 6 would no longer be valid and should be adjusted accordingly.

The pile lengths outlined in Table 6 are based on static analysis and the corresponding resistance factors outlined in Table 5. If construction specifications require dynamic analysis during pile installation as outlined in Table 10.5.5.2.3-1 of the AASHTO LRFD Bridge Design Specifications, Third Edition (including 2005 and 2006 interim revisions), the Designer may estimate pile lengths for bid documents on the appropriate resistance factor outlined in the AASHTO specifications, based on the level of field testing and construction control. The pile capacity tables in Appendices G and H also include a column of factored capacities utilizing a resistance factor (φ_{dyn}) of 0.65, which corresponds to a specific level of dynamic analysis during pile installation.

7.2.2. Hammer Energy

Static pile analyses estimate the ultimate driving resistance that 12-inch or 14-inch steel H-piles will experience during the installation process for the proposed bridge. FMSM utilized the guidelines presented in the FHWA publication "Soils and Foundations Workshop Manual" for the analyses.

The soil column contributing to driving resistance at the bridge location includes the upper clay layer and the underlying sand and gravel layers. The analyses are based on steel H-piles being driven to the maximum depths shown in Table 6 above for each of the three (3) pile types. Results of FHWA research and other literature regarding pile installation indicate that significant reductions in skin resistances occur during pile driving, primarily due to the dynamics of the installation process. Soils are remolded and pore water pressures apparently increase, causing reductions in shear strengths. The Kentucky Transportation Cabinet (KYTC) suggests the following reductions to skin resistances when estimating driving resistances:

Clay - 50%
Sands - 25%

FMSM estimated the driving resistances under the condition that no interruptions, and therefore no pile "set" characteristics would be experienced during the driving process.

Drivability analyses were conducted using the GRLWEAP (Version 2005) computer program for 12x53, 14x73 and 14x89 steel H-piles using common hammer manufactures presented in the hammer database of the GRLWEAP program. Refer to Table 7 for approximate hammer energies to drive the various piles.

Table 7. Maximum Driving Depth for Hammer Energies

Approximate Hammer Energy (ft-kips)	Depth[a] (ft)	Elevation[b] (ft)
12x53 H-pile		
20	55.1	402.1
40	73.6	383.6
60	74.0[c]	383.2[c]
14x73 H-pile		
20	50.1	407.1
40	65.6	391.6
60	75.5[c]	381.7[c]
14x89 H-pile		
20	49.6	407.6
40	65.1	392.1
60	80.0[c]	377.2[c]

[a] Depth as measured from the bottom of the pile cap.
[b] Based upon the estimated bottom of pile cap at elevation 457.2 feet.
[c] Depth/Elevation corresponding to maximum total factored axial resistance identified in Table 6.

The GRLWEAP analyses indicate that the ICE 80-5 pile hammer, which imparts approximately 80 ft kips of energy, can drive the aforementioned piles to the maximum total factored geotechnical axial resistance without developing damaging compressive or tensile stresses within the pile, and without resulting in an excessive number of hammer blows per foot of driving. The FHWA publication titled "Soils and Foundations Workshop Manual-Second Edition" defines a reasonable range of hammer blows to be between 30 and 144 blows per foot for a steel H-pile. Upon selecting pile size and length required to support the applied loads, the Designer should select the minimum hammer energy required to drive the piles to the specified depths listed in Table 7. Appendix I presents tables for H-pile driving resistances for the various pile sizes based on the soil profiles at the substructure locations. The Designer may use Appendix I in conjunction with Appendices G and H to determine a minimum driving resistance required to drive the pile to a sufficient depth to achieve the specified capacity.

7.3. Drilled Shaft Analyses

As previously stated, the foundation elements will bear in the sand horizons overlying bedrock and rely primarily on friction resistance for axial capacity. A geotechnical engineer performed axial shaft capacity estimates for 30-, 36-, 42-, and 48-inch diameter drilled shafts. FMSM utilized the procedures outlined in the Federal Highway Administration Publication No. FHWA-IF-99-025 and the computer program SHAFT version 4.0, written by Dr. Lymon L. Reese and Shin-Tower Wang, and marketed by Ensoft, Inc. to estimate axial capacities of drilled shafts. The axial capacity calculations utilize soil parameters derived from the results of the field explorations and published correlations relating SP N-values to shear strengths. Appendix F provides Idealized Soil Profiles that outline the recommended soil parameters for use in lateral load analyses. Refer to Appendices G and H for single shaft/pile nominal axial capacity estimates.

As with driven piles, the selection of LRFD resistance factors for drilled shaft capacities involve an evaluation of the type of loading (axial compression versus uplift) and the variability and reliability of models or methodologies used to determine ultimate resistance capacities. As mentioned previously, FMSM used the SHAFT 4.0 computer program to perform the load capacity calculations for the subject bridge widening. Table 8 summarizes the applicable analysis methodologies utilized in the SHAFT software as well as the resistance factors recommended by the AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 interim revisions).

Table 8. LRFD Resistance Factors for Drilled Shaft Capacity

Loading Condition	Resistance Mechanism	Analysis Methodology*	Resistance Factor** (φ)
Nominal Axial Compressive Resistance of Single Drilled Shafts	Side Resistance in Clay	α-Method	0.45
	End Bearing in Clay	Total Stress	0.40
	Side Resistance in Sand	β-Method	0.55
	End Bearing in Sand	SPT Method	0.50
Uplift Resistance of Single Drilled Shafts	Side Resistance in Clay	α-Method	0.35
	Side Resistance in Sand	β-Method	0.45

* The Designer should refer to this table for the applicable analysis methodology when determining the appropriate load factor for downdrag loads.

** From AASHTO LRFD Bridge Design Specifications, Third Edition (including 2005 and 2006 Interim Revisions), portion of Table 10.5.5.2.4-1.

Table 9 summarizes the estimated depths below the anticipated pile cap at which the proposed drilled shafts should extend in order to achieve the referenced TFGAR, based on static analysis and the resistance factors presented in Table 8 above. In accordance with Section 10.8.3.5 of the AASHTO LRFD Bridge Design Specifications, the estimated shaft lengths outlined in Table 9 were determined excluding the contribution of the top five feet to side resistance in cohesive soils.

Table 9. Summary of Drilled Shaft Capacities

Total Factored Geotechnical Axial Resistance [a]/Element (tons)	Depth [b] (ft)	Elevation [c] (ft)	Factored Geotechnical Uplift Resistance [d] (tons)
30-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	38.5	418.7	111.9
140/Piers 1 to 5	31.5	425.7	93.3
36-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	33.0	424.2	99.3
140/Piers 1 to 5	27.0	430.2	84.8
42-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	28.5	428.7	78.8
140/Piers 1 to 5	24.5	432.7	82.6
48-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	25.0	432.2	65.8
140/Piers 1 to 5	22.5	434.7	80.1

[a] Excludes any positive resistance within downdrag zone for Abutments 1 and 2.
[b] Depth as measured from the bottom of the pile cap.
[c] Based upon estimated bottom of pile cap at elevation 457.2 feet.
[d] Reported uplift resistance is for the corresponding pile length.

The Designer should note that these estimates are for the TFGAR listed above. Should more or less capacity be required for each shaft at the pier locations, refer to the capacity tables presented in Appendix H because the piers are not affected by downdrag. However, the shaft capacity tables presented in Appendix G for the abutment are valid for the specified TFGAR only. The length estimates at the abutment locations are based on the shaft capacities presented in Table 9 and the length of shaft subjected to downdrag. Should more or less capacity be required, the Designer should consult FMSM because the downdrag load and length of shaft subjected to downdrag are a function of shaft length. Additionally, should the elevation of the bottom of the pile cap change, shaft lengths and elevations presented in Table 9 would no longer be valid and should be adjusted accordingly.

8. Embankment Stability Analyses

The ahead-station approach embankment is approximately 27 feet tall at the proposed location of Abutment 2. FMSM evaluated the global stability of the approach embankment-abutment-wingwall system at this location utilizing the REAME (Rotational Equilibrium Analysis of Multi-Layered Embankments) 2004 slope stability program, developed by Dr. Y.H. Huang at the University of Kentucky. The program estimates a circular (rotational) failure surface and calculates the factor of safety based on the Simplified Bishop method of slices. Short-term analyses using total-stress shear-strength parameters for the foundation and embankment materials simulate conditions that will exist immediately following the construction of the embankment. Long-term analyses, using effective-stress shear-strength parameters, simulate conditions that will exist long after the embankment is constructed and excess pore pressures within the materials have dissipated. The current edition of the Kentucky Transportation Cabinet (KYTC) Geotechnical Manual presents target factors of safety for embankment stability situations. Table 10 summarizes these values.

Table 10. Target Factors of Safety Embankment Stability Analyses

	Short ? Term	Long ? Term
Bridge Approach Slopes	1.2 ? 1.4	1.6 ? 1.8

At the Abutment 2 location, short- and long-term analyses returned factors of safety of 1.3 and 1.7, respectively. These values meet or exceed the KYTC target values outlined in Table 10. Subsurface Data Sheet 4 of 4 in Appendix C presents results of the slope stability analyses, including predicted minimum factors of safety, predicted failure surfaces, and modeled groundwater table positions.

9. Settlement Analyses, Downdrag Estimates, and Lateral Squeeze Potential

9.1. Settlement Analyses

Project plans indicate the ahead-station approach embankments for the proposed bridge construction will be on the order of 27 feet in height. The subsurface exploration program indicates the foundation soils at the abutment locations consist of approximately 10 feet of clayey materials overlying sands up to a depth of approximately 120 feet. A geotechnical engineer performed settlement analyses at Abutment 2, the back-station approach, to

estimate the settlement of the foundation soils resulting from embankment construction and to evaluate the potential for negative skin friction or downdrag loads on the deep foundation elements.

FMSM estimated settlement parameters for the foundations soils based on the results of the previously discussed laboratory testing. The geotechnical engineer estimated consolidation parameters for the clay type soils using the results of one-dimensional consolidation testing from nearby borings with similar engineering classifications. Settlement parameters for the granular (non-cohesive) materials were estimated based on corrected SP N-values correlated with laboratory classification testing as outlined in the guidelines presented in the FHWA Soils and Foundations Workshop Manual ? Second Edition, pages 168 through 170. Subsurface Data Sheet 4 of 4 in Appendix C presents the estimated settlement parameters derived for each soil horizon.

FMSM performed settlement analyses at approximate Ramp 3, Station 42+00, 5 feet left. These estimates indicate that approximately 4.1 inches of settlement of the foundation soils may occur at the planned location of Abutment 2 as a result of the widening of the ahead-station approach embankment. Time rate of settlement calculations suggest that an estimated 5 weeks may be required following completion of the embankment to achieve primary consolidation (90% of total settlement) of the clay soils. Table 11 provides a summary of the settlement analyses performed for the subject bridge structure.

Table 11. Summary of Settlement Analyses

Location	Estimated Settlement Clay (in.)	Sands (in.)	Total (in.)	Approximate Time Required for Primary Consolidation of Cohesive Soils (days)	(weeks)
Abutment 2 (Ahead-Station Approach)	2.8	1.3	4.1	35	5

The Designer should note that settlement experienced at the proposed Abutment 2 location will have the effect of differential settlement with respect to the existing embankment and foundations of existing structures nearby.

As discussed, construction of the proposed approach embankments will result in settlement of the underlying foundation soils. Based on the anticipated construction sequencing (installation of foundation elements at the abutment locations, construction of the planned breast wall, then construction of the embankment) the Designer should be aware that settlement will occur in the sand foundation soils below the tip elevation of the deep foundation elements. Settlement of the sands beneath the foundation elements will result in settlement of the pile/shaft group. It should be noted that this settlement is a concern only at the abutment locations and is a result of construction of the embankment behind the breast wall abutment not a result of structural loads placed on the shaft/pile group. Based on settlement calculations performed for the subject bridge structure and length estimates for the deep foundation elements, FMSM estimates this settlement to be less than ¼-inch for the pile foundation option and on the order of ½ to ¾-inch for the drilled shaft option. Because of the cohesionless nature of the soils beneath the tip elevation of the deep foundation elements, this settlement should occur during construction of the embankment. The Contractor should be prepared to accommodate this settlement during construction.

9.2. Downdrag Estimates

Based on the anticipated loads and the subsurface profile at the bridge site, FMSM is recommending that the foundation systems for the bridge construction consist of deep foundation elements bearing in the sand horizons above the underlying bedrock. The settlement analyses presented in Section 9.1 of this report indicate that the clay and sand foundation soils at the Abutment 2 location may experience 4.1 inches of settlement due to construction of the planned ahead-station approach embankment. Approximately 2.8 inches of the estimated settlement will be consolidation within the clay layer underlying the embankment and 1.3 inches of the settlement will occur within the sands. Studies indicate that as little as 0.1 to 0.5 inches (3 to 12 mm) of settlement is sufficient to mobilize negative skin friction forces at the shaft/pile-soil interface. It is our understanding that the foundation elements will be constructed prior to fill placement as part of the embankment widening. Therefore, the proposed shafts/piles at this location will be subject to negative skin friction.

FMSM performed calculations to estimate downdrag loads resulting from settlement of the foundation soils in relation to the planned deep foundation elements. As recommended by the AASHTO LRFD Bridge Design Specifications, the downdrag analyses are based on relative soil movements of 0.4 inches between the foundation elements and the surrounding soil mass. The calculations are based on the lengths outlined in Tables 6 and 9 for the maximum total factored geotechnical axial resistance of the piles and for 140-ton shafts. If the bridge design requires different lengths or capacities, the Designer should contact FMSM to re-evaluate the downdrag loads on the foundation elements. The calculations are based upon methods outlined in FHWA-HI-97-013 and FHWA-IF-99-025, which utilize soil strengths and effective stresses within the soil horizons. Table 12 outlines the potential negative skin friction estimates for both driven pile and drilled shaft foundation options.

Table 12. Estimated Maximum Downdrag Loads for Foundation Elements at Abutments 1 and 2

Foundation Element Type	Total Factored Geotechnical Axial Resistance (tons)	Estimated Tip Elevation * (ft)	Estimated Element Length Subjected to Downdrag (ft)	Estimated Maximum Downdrag Load (kips)	Estimated Maximum Downdrag Load (tons)
12x53 Steel H-Pile	100	377.7	33.7	153.0	76.5
14x73 Steel H-Pile	140	376.2	33.7	203.4	101.7
14x89 Steel H-Pile	170	371.2	35.8	244.4	122.2
30" Drilled Shaft	140	418.7	18.9	158.6	79.3
36" Drilled Shaft	140	424.2	17.1	154.0	77.0
42" Drilled Shaft	140	428.7	15.3	140.2	70.1
48" Drilled Shaft	140	432.2	13.2	112.0	56.0

* As outlined in Tables 6 and 9

** As measured downward from the bottom of the pile cap (Elev. 457.2 ft)

Because of the anticipated construction sequencing and schedule for construction of the planned bridge, a waiting period for anticipated settlement is not realistic prior to installation of the deep foundation elements. Therefore, the downdrag/negative skin friction forces should be considered in the design of the foundation elements.

9.3. Lateral Squeeze

Studies conducted by the FHWA have shown that some bridge end bents supported on piles driven through thick deposits of compressible soils have tilted or rotated toward the embankment. The condition causing the structural deformation is the unbalanced fill loading on the area surrounding the end bents, which causes the foundation soils to move (squeeze) laterally. This squeeze can transmit a large lateral thrust along the length of the piles embedded within the compressible foundation soils, resulting in the tops of the piles rotating towards the embankment.

FHWA guidelines suggest that if the pressure exerted by the weight of the embankment exceeds three times the undrained shear strength of the foundation soils, the potential for lateral squeeze exists. The clay layer at the bridge site varies from about 0 to 18.5 feet in thickness, extending from the ground surface down to approximate elevation 442.4 feet at its lowest point based on the borings drilled for the subject bridge structure. A review of the subsurface data indicates the undrained shear strength of the clay soils varies from 580 to 1,600 psf. A design value of 750 psf, derived from the test data obtained for this bridge, was used to evaluate the potential for lateral squeeze. The planned approach embankments are about 27 feet in height, resulting in pressures exerted at the middle of the underlying clay layer on the order of 2,410 psf using the LRFD Service I Load combination. Based on the noted criteria, the embankment loading exceeds three times the undrained shear strength of the foundation soils (3C=3x750=2,250 psf), indicating that the potential for lateral squeeze exists and should be considered in the design of the foundation system. The FHWA "Soils and Foundation Workshop Manual" suggests that the anticipated lateral movement resulting from lateral squeeze may be estimated as 25 percent of the fill settlement. A settlement analysis was conducted at the Abutment 2 location and the analysis yielded an estimated settlement of approximately 4.1 inches. Thus, the lateral deformation of the abutment is estimated to be on the order of one inch. However, because the applied bearing pressure (2,410 psf) is only marginally greater than the soil shear strength criteria (2,250 psf), the lateral deformation realized in the field is likely to be less than that estimated by the referenced procedure.

10. Seismic Design Considerations

10.1. General

The 2004 AASHTO LRFD Bridge Design Specifications provides guidelines for selecting a seismic performance category and a soil profile type for bridge sites. This information establishes the elastic seismic response coefficient and spectrum for use in further structural design and analyses.

According to these guidelines, the bridge site classifies as Seismic Performance Category A, with an acceleration coefficient (A) of approximately 0.06 with a 90 percent probability of not being exceeded in 50 years (based on 1988 NEHRP mapping included in the AASHTO LRFD Bridge Design Specifications, Third Edition). It is recommended that Soil Profile Type I soils be used in selecting the site coefficient (S). Further seismic analyses were beyond the scope of FMSM's work for this project.

10.2. Liquefaction Potential on On-Site Soils

Liquefaction of soils is a phenomenon that may occur during seismic loading when a loose, saturated soil deposit experiences loss of shear strength. The short duration, cyclic loading induced by an earthquake increases the pore-water pressure in the soil skeleton, which, in turn, decreases the effective stress, resulting in a decrease in the soils shear strength. If the pore water pressure becomes equal to the total stress acting on the soil, the effective stress becomes zero and liquefaction occurs.

Factors that affect the liquefaction susceptibility of a soil deposit are:

- Soil Structure
- Grain Characteristics
- Relative Density
- Confining Pressure
- Maximum Ground Acceleration
- Duration of Earthquake

Soil structure constitutes both the geometric arrangement of soil particles and the interparticle forces, which act between them. Loose, cohesionless soils tend to be more susceptible to liquefaction than soils which are dense or in which cohesion constitutes significant parts of their shear strengths.

Grain characteristics of a soil are important in evaluating liquefaction susceptibility. Generally, soils with grain sizes equal to or smaller than the size of sand may be susceptible to liquefaction, depending on interparticle forces and/or density. Evidence is available to support that uniformly graded soils tend to be more susceptible to liquefaction and that fine sands tend to liquefy more readily than clays, silts, or gravely soils.

Determination of in situ relative density is also important in determining a soils liquefaction susceptibility. Loosely deposited soils, in which in situ density is low relative to the maximum density, are more likely to liquefy than densely deposited soils. It has been shown that contractive soils (soils which tend to decrease in volume during shearing) may experience a loss of strength during shearing and subsequent liquefaction, while dilative soils (soils which tend to increase in volume during shearing) are less susceptible to this same strength loss and subsequent liquefaction.

Considerable data show that liquefaction potential of a soil is reduced by increasing the confining pressure. Consequently, liquefaction is less likely to occur at greater depths where confining pressures are higher.

Lower specific gravity has two effects on liquefaction susceptibility. First, confining pressure is lower, thus liquefaction potential in increased; and second, shear stresses induced during an earthquake are lower due to lower soil unit weights; thus liquefaction potential is decreased. The lower specific gravity of soils, therefore, has both positive and negative effects on liquefaction susceptibility.

Liquefaction potential is also very dependent on the magnitude of ground acceleration and duration of an earthquake. Obviously, a strong earthquake would increase the likelihood of liquefaction.

Based on these criteria, a review of drilling, sampling, and laboratory testing performed for this project; and the seismic categorization summarized in Section 10.1 of this report; it is FMSM′s opinion that if the following recommendations for foundation construction are implemented, a detailed study to determine the liquefaction potential for soils at this site is not warranted.

11. Foundation System Recommendations

FMSM developed the following recommendations based upon reviews of available data, information obtained during the field exploration, results of laboratory testing and engineering analyses, and discussions with the Designer and KYTC personnel. The recommendations are also based on the structure configuration presented in drawings downloaded from the KTA ProjectWise website on June 5, 2006.

11.1. General

11.1.1. General recommendations provided herein are based on the structure configuration presented in drawings downloaded from the KTA ProjectWise website on June 5, 2006. Construction of the approach embankments for the subject bridge will involve widening of the existing interstate embankment. Project plans indicate the ahead-station approach embankments will be on the order of 27 feet in height. The subsurface exploration program indicates the foundation soils at the abutment locations consist of approximately 10 feet of clayey materials overlying sands up to a depth of approximately 120 feet. The settlement analyses presented in Section 9.1 of this report indicate that the clay and sand foundation materials may experience settlement on the order of 4.1 inches. Approximately 2.8 inches of the settlement will be consolidation within the clayey material and 1.3 inches will occur within the underlying sands. AASHTO specifications indicate that as little as 0.4 inches of settlement is sufficient to mobilize negative skin friction. Therefore, it is recommended that the design of steel H-pile and/or drilled shaft foundation elements include the anticipated down-drag forces. The maximum downdrag estimates provided in Section 9.2 of this report are for the maximum total factored geotechnical axial resistance of steel H-piles and a 140-ton factored geotechnical axial resistance for drilled shafts installed to the estimated elevations outlined in Table 6 and 9 only. If the bridge design requires different lengths or capacities, the Designer should contact FMSM to re-evaluate the downdrag loads on the foundation elements.

11.1.2. Because the abutments will be breast wall abutments, the construction sequence will not allow a waiting period for settlement to occur prior to installing foundation elements. Therefore, one of the following alternatives may be implemented to reduce the downdrag loads:

a. Design (size) the piles to accommodate all the estimated down-drag forces.

b. Design the structure to tolerate the full amount of settlement resulting from the down-drag and the other applied loads.

c. Coat piles with bitumen slip layer to allow movement between the soil and the piles. Current practice allows for as much as 90 percent reduction in downdrag forces with this method.

d. Predrill and provide a polypropylene or steel sleeve for the pile to reduce down-drag. This method only prevents contact between the pile and adjacent soils.

e. Design the embankment with lightweight fill to reduce the overall settlement of the foundation soils.

f. Substitute an MSE wall with a stub type abutment for the full-height CIP breast wall abutment and allow the settlement to occur before the piles are installed.

If consolidation of foundation soils is allowed to occur prior to driving the piles, which could be an option with item f. (MSE wall), the piles do not need to be designed to accommodate down-drag loads. Also, allowing the foundation soils to consolidate will reduce the potential for abutment rotation associated with lateral squeeze. With the MSE wall option, a wick drain system could be designed and installed to accelerate consolidation of the foundation soils. If this is considered a viable option, the geotechnical consultant should be contracted to assist in the design of such a system.

11.1.3. It should be noted from the AASHTO LRFD Bridge Design Specifications, Third Edition (including 2005 and 2006 Interim Revisions) that the application of downdrag loads to pile or shaft groups can be complex. If the pile or shaft cap is near or below the fill material causing consolidation settlement of the underlying soft soil, the cap will prevent transfer of stresses adequate to produce settlement of the soil inside the pile or shaft group. The downdrag applied in this case is the frictional force around the exterior of the pile or shaft group and along the sides of the pile or shaft cap (if any). If the cap is located well up in the fill causing consolidation stresses or if the piles or shafts are used as individual columns to support the structures above the ground, the downdrag on each individual pile or shaft will control the magnitude of the load. If group effects are likely, the downdrag load calculated using the group perimeter shear force should be determined in addition to the sum of the downdrag forces for each individual pile or shaft. The greater of the two calculations should be used for design.

11.1.4. Foundation excavations should be properly braced/shored to provide adequate safety to people working in or around the excavations. Bracing should be performed in accordance with applicable federal, state and local guidelines.

11.1.5. The Contractor should be made aware that the subject bridge will be constructed near existing buildings. To better understand the source of construction vibrations and how they are attenuated to the existing buildings, it is recommended that a program be developed to record peak particle velocities (PPV) prior to and during roadway construction. Digital seismograph units should be placed between roadway construction activities and the existing structures.

11.1.6. The largest peak particle velocities that will be generated at surrounding buildings by proposed nearby construction activities are unknown at this time. It is recommended that a pile driving test program be performed prior to the installation of the production piles, and a preconstruction survey of existing structural defects of nearby structures be conducted and documented before the beginning of pile driving. This test program can be used to help establish threshold PPVs for the surrounding area and equipment.

11.1.7. The Designer may use the information provided herein to aid in the design ofthe foundation systems. Should the Designer require pile/shaft capacities other than the factored geotechnical axial resistances provided (more or less), the geotechnical consultant should be contacted to assist the Designer. It should be noted that the downdrag load and length of pile/shaft subjected to downdrag is a function of the design capacity/length of the foundation element. The geotechnical consultant is available to assist the Designer during foundation design.

11.1.8. Based on the AASHTO LRFD Bridge Design Specifications, Third edition (Including 2005 and 2006 interim revisions), the bridge site classifies as Seismic Performance Category A, with an acceleration coefficient (A) of 0.06, with a 90 percent probability of not being exceeded in 50 years (base on the 1988 NEHRP map included in the referenced edition of the AASHTO specifications). It is recommended that Soil Profile Type I soils be used in selecting the site coefficient (S).

11.2. Steel H-Pile Option

11.2.1. The following table provides estimated pile lengths applicable for the recommended maximum total factored geotechnical axial resistances (TFGAR) at both the pier and abutment locations. The Designer should note that these estimates are for the TFGAR referenced in the following table only. Should more or less capacity be required for each pile at the <u>pier locations</u>, refer to the capacity tables presented in Appendix H because the piers are not affected by downdrag. However, the tables presented in Appendix G for the abutments are valid for the specified TFGAR only. The length estimates at the <u>abutment</u>

locations are based on the pile capacities presented in the table and length of pile subjected to downdrag. Should more or less capacity be required, the Designer should consult FMSM because the downdrag load and length of pile subjected to downdrag are a function of pile length.

Summary of Driven Pile Capacities

Maximum Total Factored Geotechnical Axial Resistance[a]/Element (tons)	Depth[b] (ft)	Elevation[c] (ft)	Total Factored Geotechnical Uplift Resistance[d] (tons)
12x53 H-pile			
100/ Abutments 1 and 2	74.0	383.2	101.6
100/Piers 1 to 5	62.0	395.2	76.3
14x73 H-pile			
140/Abutments 1 and 2	75.5	381.7	141.6
140/Piers 1 to 5	63.5	393.7	106.8
14x89 H-pile			
170/Abutments 1 and 2	80.0	377.2	171.0
170/Piers 1 to 5	67.5	389.7	129.9

[a] Excludes any positive resistance within downdrag zone for Abutments 1 and 2.
[b] Depth as measured from the bottom of the pile cap.
[c] Based upon estimated bottom of pile cap at elevation 457.2 feet.
[d] Reported uplift resistance is for the corresponding pile length.

11.2.2. The TFGAR estimates provided in Appendices G and H were derived usingthe following LRFD resistance factors, as recommended by the AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 Interim Revisions).

Loading Condition	Resistance Mechanism	Analysis* Methodology	Resistance Factor** (φ)
Nominal Resistance of Single Pile in Axial Compression ? Static Analysis	Skin Friction and End Bearing ? Clay and Mixed Soils	α-Method	0.35
	Skin Friction and End Bearing ? Sand	Nordlund/Thurman Method	0.45
Uplift Resistance of Single Piles - Static Analysis	Side Resistance in Clay	α-Method	0.25
	Side Resistance in Sand	Nordlund Method	0.35

* The designer should refer to this table for the applicable analysis methodology when determining the appropriate load factor for downdrag loads.

** From AASHTO LRFD Bridge Design Specifications, Third Edition (including 2005 and 2006 Interim Revisions), portion of Table 10.5.5.2.3-1

11.2.3. If load testing and/or dynamic analysis of driven piles in soil is conducted, the LRFD resistance factors used to determine the factored axial capacity for design purposes may be revised as outlined in Table 10.5.5.2.3-1 of the AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 Interim Revisions) based on site variability and the number and type of tests performed. The Designer should note that lateral capacity requirements will need to be revisited if the pile lengths are revised based on load testing and/or dynamic analysis.

11.2.4. As noted, all pile capacities presented in Appendices G and H are for single piles. In addition to applying appropriate resistance factors, individual capacities for piles in group configurations may be further reduced depending upon soil type, bearing condition of the pile cap, or center-to-center spacing as recommended in the current edition of the AASHTO LRFD Bridge Design Specifications. The following criteria should be observed:

CTC Spacing	Group Efficiency Factor		
	Cohesive Soils		Cohesionless Soils
	Cap not in firm Contact with Ground	Cap in firm Contact with Ground	Cap in or not in firm Contact with Ground
6B	1.00	1.00	1.00
2.5B	0.65	1.00	1.00

The notation "B" is the shaft diameter and the percent reduction can be linearly interpolated between the values and spacing provided.

11.2.5. The AASHTO LRFD Bridge Design Specifications recommend a resistance factor for horizontal geotechnical resistance of a single pile or pile group of 1.0 for lateral capacity analyses. Appendix F provides Idealized Soil Profiles that outline the recommended soil parameters for use in lateral load analyses.

11.2.6. Use Grade 50 steel H-piles as friction piles. Piles should be driven to the target elevation and then left for a minimum of one day to allow for dissipation of excess pore pressures caused by the pile installation process. This should allow the soil to "set-up". After the one day waiting period, re-strike the piles to see if an adequate capacity has been achieved.

11.2.7. Hammer energies which could drive the pile section were based on the ultimate driving resistance that 12x53, 14x73 and 14x89 steel H-piles would experience during the installation process. The results of these calculations are presented in the following table.

Maximum Driving Depth for Hammer Energies

Approximate Hammer Energy (ft-kips)	Depth[a] (ft)	Elevation[b] (ft)
12x53 H-pile		
20	55.1	402.1
40	73.6	383.6
60	74.0[c]	383.2[c]
14x73 H-pile		
20	50.1	407.1
40	65.6	391.6
60	75.5[c]	381.7[c]
14x89 H-pile		
20	49.6	407.6
40	65.1	392.1
60	80.0[c]	377.2[c]

[a] Depth as measured from the bottom of the pile cap.
[b] Based upon the estimated bottom of pile cap at elevation 457.2 feet.
[c] Depth/Elevation corresponding to the maximum TFGAR.

11.2.8. Upon selecting the pile size and length required to support the applied loads, the Designer should select the minimum hammer energy required to drive the piles to the specified depths from the table presented in 11.2.7. above. The Designer should place a note on the drawings that states: A hammer system capable of delivering a minimum energy of ___foot-kips will be necessary to drive the piles to the maximum total factored geotechnical axial resistance without encountering excessive blow counts and over-stressing the piles. The Contractor should submit appropriate pile driving systems to the Kentucky Transportation Cabinet for approval prior to the installation of the first pile. Approval of the pile driving system by the Engineer will be subject to satisfactory field performance of the pile driving procedures.

11.2.9 Upon selecting the pile size and length required to support the applied loads, the Designer should select the minimum driving resistance required to install the pile to the design depth from the tables provided in Appendix I. This driving resistance should be reported to the Contractor to aid in determining when/if the pile has been driven to a sufficient depth to achieve the specified capacity.

11.2.10. Pile types, driving systems and installations should conform to current AASHTO Standard Specifications for Highway Bridges unless otherwise specified.

11.2.11. Drivability studies were performed assuming continuous driving. If interruptions in driving individual piles should occur, difficulties in continuing the installation process will likely occur due to pile "set-up" characteristics.

11.2.12. The AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 Interim Revisions) recommends the following resistance factors for determining the structural capacity of steel H-piles.

Loading Condition	Resistance Factor*	
	Piles Subjected to Damage From Severe Driving Conditions**	Good Driving Conditions
Axial Resistance In Compression	$\varphi_c = 0.50$	$\varphi_c = 0.60$
Combined Axial and Flexural Resistance	N/A	$\varphi_c = 0.70$ $\varphi_f = 1.00$

* As specified in Section 6.5.4.2 of the AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 Interim Revisions)

** Apply these values only to the section of the pile likely to be damaged during driving (Section 6.15.2 of the AASHTO Specifications)

11.2.13. The capacity of the steel H-piles shall also consider the anticipated negative skin resistance/downdrag loads. AASHTO LRFD Bridge Design Specifications indicate that for friction piles subjected to downdrag loading, downdrag shall be considered at the service, strength and extreme limit states.

11.2.14. Construction of the proposed approach embankment will result in settlement of the underlying foundation soils. Based on the anticipated construction sequencing (installation of foundation elements at the abutment locations, construction of the planned breast wall, then construction of the embankment) the Designer should be aware that settlement will occur in the sand foundation soils <u>below</u> the tip elevation of the deep foundation elements at the abutment locations, resulting in settlement of the pile group. Based on settlement calculations performed for the subject bridge structure and length estimates for the deep foundation elements, FMSM estimates this settlement to be less than ¼-inch for the pile foundation option. Because of the cohesionless nature of the soils beneath the tip elevation of the piles, this settlement should occur during construction of the embankment. The Contractor should be prepared to accommodate this settlement during construction.

11.3. Drilled Shaft Option

11.3.1. Drilled Shaft Integrity Testing will be required for each drilled shaft. An appropriate number of Crosshole Sonic Logging (CSL) access tubes (approximately 3), consisting of two (2) inch nominal diameter schedule 40 steel pipe, will be required. These tubes should be shown on the drilled shaft details with the following note on the Drilled Shaft Detail Sheet:

> Perform non destructive Drilled Shaft Integrity Testing on the Drilled Shafts using Crosshole Sonic Logging (CSL) in accordance with the "Special Note for Non-Destructive Testing of Drilled Shafts". The Department will pay for this testing and
>
> associated costs at the contract unit bid price for "CSL Testing". This includes CSL Testing Mobilization and CSL Testing. The access tubes are incidental to the shaft.

11.3.2. The following table provides estimated drilled shaft lengths applicable for the recommended maximum TFGAR at both the pier and abutment locations. The Designer should note that these estimates are for the maximum TFGAR referenced in the following table only. Should more or less capacity be required for each pile at the <u>pier locations</u>, refer to the capacity tables presented in Appendix H because the piers are not affected by downdrag. However, the tables presented in Appendix G for the abutments are valid for the specified TFGAR only. The length estimates at the abutment locations are based on the shaft capacities presented in the table and length of shaft subjected to downdrag. Should more or less capacity be required, the Designer should consult FMSM because the downdrag load and length of shaft subjected to downdrag are a function of shaft length.

Summary of Drilled Shaft Capacities

Total Factored Geotechnical Axial Resistance[a]/Element (tons)	Depth[b] (ft)	Elevation[c] (ft)	Factored Geotechnical Uplift Resistance[d] (tons)
30-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	38.5	418.7	111.9
140/Piers 1 to 5	31.5	425.7	93.3
36-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	33.0	424.2	99.3
140/Piers 1 to 5	27.0	430.2	84.8
42-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	28.5	428.7	78.8
140/Piers 1 to 5	24.5	432.7	82.6
48-Inch Diameter Drilled Shaft			
140/Abutments 1 and 2	25.0	432.2	65.8
140/Piers 1 to 5	22.5	434.7	80.1

[a] Excludes any positive resistance within downdrag zone for Abutments 1 and 2.
[b] Depth as measured from the bottom of the pile cap.
[c] Based upon estimated bottom of pile cap at elevation 457.2 feet.
[d] Reported uplift resistance is for the corresponding pile length.

11.3.3. The TFGAR estimates provided in Appendices G and H were derived using the following LRFD resistance factors as recommended by the AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 Interim Revisions).

Loading Condition	Resistance Mechanism	Analysis Methodology*	Resistance Factor** ($\boldsymbol{\varphi}$)
Nominal Axial Compressive Resistance of Single Drilled Shafts	Side Resistance in Clay	α-Method	0.45
	End Bearing in Clay	Total Stress	0.40
	Side Resistance in Sand	β-Method	0.55
	End Bearing in Sand	SPT Method	0.50
Uplift Resistance of Single Drilled Shafts	Side Resistance in Clay	α-Method	0.35
	Side Resistance in Sand	β-Method	0.45

* The Designer should refer to this table for the applicable analysis methodology when determining the appropriate load factor for downdrag loads.

** From AASHTO LRFD Bridge Design Specifications, Third Edition (including 2005 and 2006 Interim Revisions), portion of Table 10.5.5.2.4-1

11.3.4. If load testing of drilled shafts in soil is conducted, the LRFD resistance factors used to determine the factored axial capacity for design purposes may be revised as outlined in Table 10.5.5.2.4-1 of the AASHTO LRFD Bridge Design Specifications, Third Edition (including the 2005 and 2006 Interim Revisions) based on the number of tests performed and site variability. The Designer should note that lateral capacity requirements will need to be revisited if the shaft lengths are revised based on load testing.

11.3.5. As noted, all shaft capacities presented in Appendices G and H are for single shafts. In addition to applying appropriate resistance factors, individual capacities for shafts in group configurations should be further reduced depending upon center-to-center spacing as recommended in the current edition of the AASHTO LRFD Bridge Design Specifications. The following criteria should be observed:

CTC Spacing	Group Efficiency Factor for Cohesive Soils	Group Efficiency Factor for Non-Cohesive Soils
6B	1.00	N/A
4B	0.80	1.00
2.5B	0.65	0.65

The notation "B" is the shaft diameter and the percent reduction can be linearly interpolated between the values and spacing provided.

11.3.6. The AASHTO LRFD Bridge Design Specifications recommend a resistance factor for horizontal geotechnical resistance of a single shaft or shaft group of 1.0 for lateral capacity analyses. Appendix F provides Idealized Soil Profiles that outline the recommended soil parameters for use in lateral load analyses.

11.3.7. The Contractor should embed the drilled shafts to the plan tip elevation or to an elevation as directed by the Engineer.

11.3.8. If temporary casing for drilled shafts is used during construction, the Contractor should either wait until concrete has been placed for the entire length of the shaft before pulling the casing, or the level of the concrete being placed should be maintained several feet above the hydrostatic head as the casing is retrieved. These measures should be implemented by the Contractor to reduce the likelihood of soils collapsing into the shaft excavation and detrimentally affecting the structural integrity of the drilled shafts.

11.3.9. It is recommended that Class A Modified concrete in accordance with the current KYTC Special Note for Drilled Shafts be used in construction of the drilled shafts. The concrete should also exhibit good workability, i.e., high slump. Once an excavation is complete and the steel reinforcing cage has been placed, concrete should be tremmied to the bottom of the shaft and should replace/displace any water or slurry remaining after drilling operations.

11.3.10. If drilling slurry is to be used during drilled shaft installations, the slurry should be capable of suspending the soil particles encountered and not leave a thick coating of slurry, or "mud", on the excavation sides or bottom. In accordance with the current "Special Note for Drilled Shafts", the Contractor shall submit a detailed plan for its use and disposal along with a drilled shaft installation plan to the Geotechnical Branch of the Kentucky Transportation Cabinet for approval prior to implementation. The Contractor shall supply all equipment and construction techniques involving slurry that are necessary to maintain environmental standards.

11.3.11. Unless otherwise specified, all construction methods and materials used for drilled shaft installations shall be in accordance with the current "Special Note for Drilled Shafts".

11.3.12. The capacity of the shafts shall also consider the anticipated negative skin resistance/downdrag loads. AASHTO LRFD Bridge Design Specifications indicate that for friction shafts subjected to downdrag loading, downdrag shall be considered at the service, strength and extreme limit states.

11.3.13. Construction of the proposed approach embankment will result in settlement of the underlying foundation soils. Based on the anticipated construction sequencing (installation of foundation elements at the abutment locations, construction of the planned breast wall, then construction of the embankment) the Designer should be aware that settlement will occur in the sand foundation soils <u>below</u> the tip elevation of the deep foundation elements at the abutment locations, resulting in settlement of the shaft group. Based on settlement calculations performed for the subject bridge structure and length estimates for the deep foundation elements, FMSM estimates this settlement to be on the order of ½ to ¾-inch for the drilled shaft foundation option. Because of the cohesionless nature of the soils beneath the tip elevation of the shafts, this settlement should occur during construction of the embankment. The Contractor should be prepared to accommodate this settlement during construction.

12. Closing

12.1. The conclusions and recommendations presented herein are based on data and subsurface conditions from the borings drilled during the March, April and May 2006 exploration using that degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. No warranties can be made regarding the continuity of conditions between borings.

12.2 General soil and rock descriptions and indicated boundaries are based on an engineering interpretation of all available subsurface information and may not necessarily reflect the actual variation in subsurface conditions between borings and samples. Collected data and field interpretation of conditions encountered in individual borings are shown on the drafted sheets in Appendix C.

12.3. The observed water levels and/or conditions indicated on the boring logs are as recorded at the time of exploration. These water levels and/or conditions may vary considerably, with time, according to the prevailing climate, rainfall, tail water elevations or other factors and are otherwise dependent on the duration of and methods used in the exploration program.

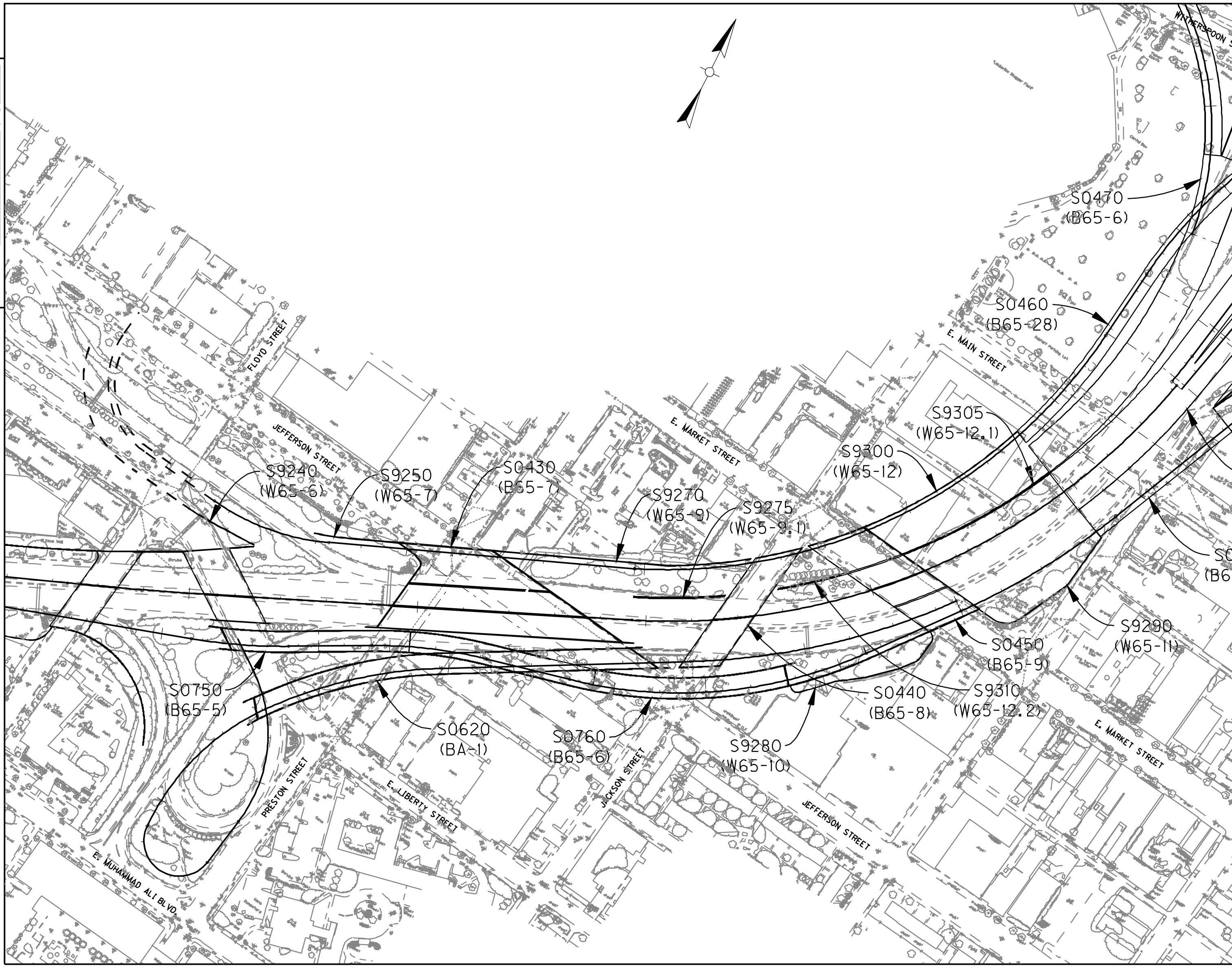
12.4. FMSM exercised sound engineering judgment in preparing the subsurface information presented herein. This information has been prepared and is intended for design and estimating purposes. Its presentation on the plans or elsewhere is for the purpose of providing intended users with access to the same information available to the KYTC. This subsurface information interpretation is presented in good faith and is not intended as a substitute for personal investigations, independent interpretations or judgments of the Contractor.

12.5. All structure details shown herein are for illustrative purposes only and may not be indicative of the final design conditions shown in the contract plans.

Appendix A

Location Map

COUNTY OF	ITEM NO.	SHEET NO.
JEFFERSON	5-118.18/.19	



SCALE: 1"=100'

KENNEDY INTERCHANGE
SECTION 1
PHASE 1
JEFFERSON COUNTY,
LOUISVILLE, KENTUCKY
ITEM NOS. 5-118.18 & 19

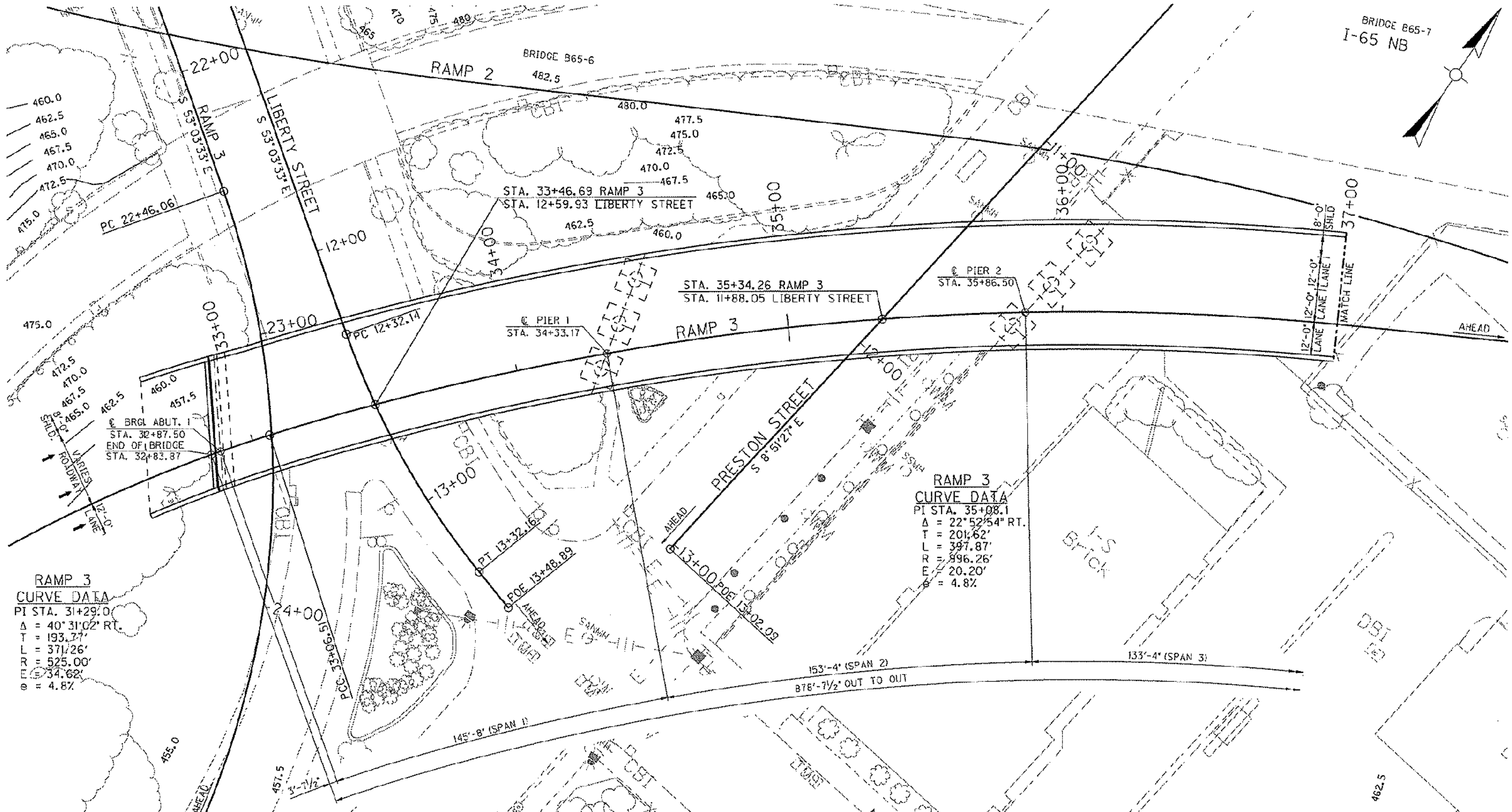
VICINITY MAP

PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

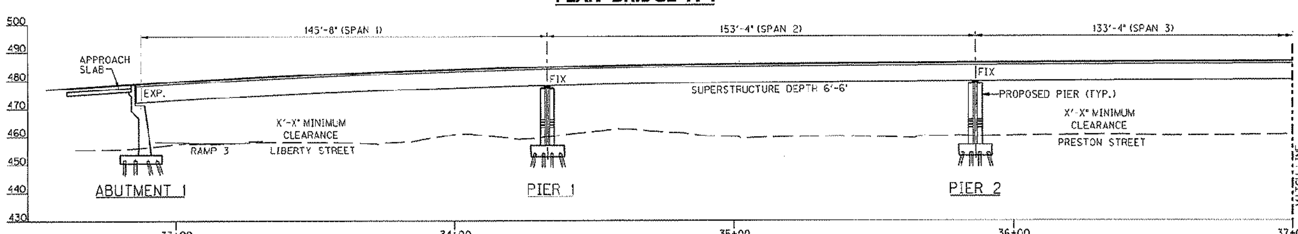
USER: $$$$USER$$$$
DATE: $$$$DATE$$$$
FILE NAME: $$$$designsfile$specifications$$$$
E-SHEET NAME:

Appendix B

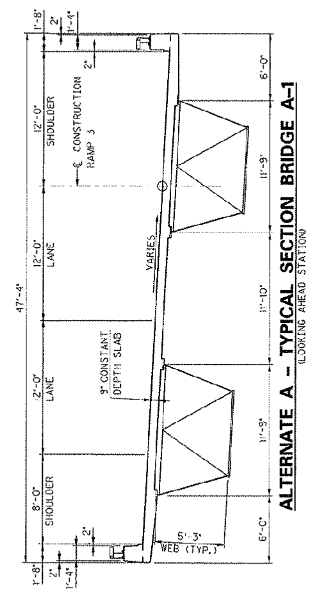
Client Drawings from ProjectWise



PLAN BRIDGE A-1

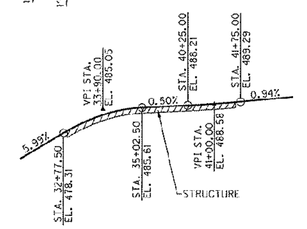


SECTION ALONG PROFILE GRADE BL RAMP 3



ALTERNATE A – TYPICAL SECTION BRIDGE A-1

(LOOKING AHEAD STATION)



RAMP 3 PROFILE GRADE

NOTE:
FOR ALTERNATE B TYPICAL SECTION SEE SHEET

S0620-LAYO1.DGN DOWNLOADED FROM PROJECTWISE ON 6-5-06

REVISION	DATE

DATE: CHECKED BY:
DESIGNED BY:
DETAILED BY:

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
JEFFERSON

ROUTE: RAMP 3 — CROSSING: LIBERTY, PRESTON, JEFFERSON STREET

LAYOUT BRIDGE A-1

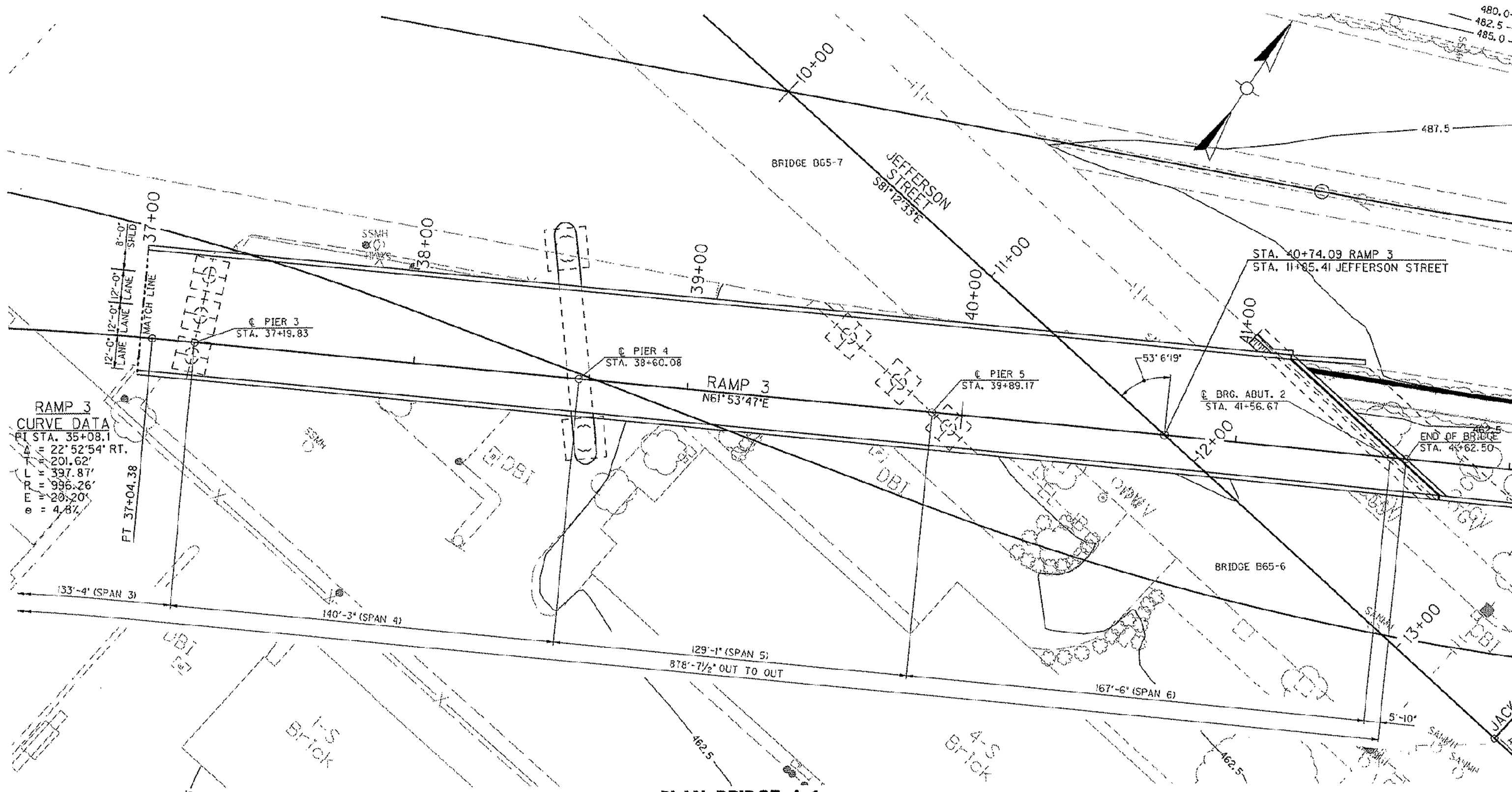
PREPARED BY: THE OHIO RIVER BRIDGES — Kentucky Transportation Associates

SHEET NO.
DRAWING NO.

ITEM NUMBER

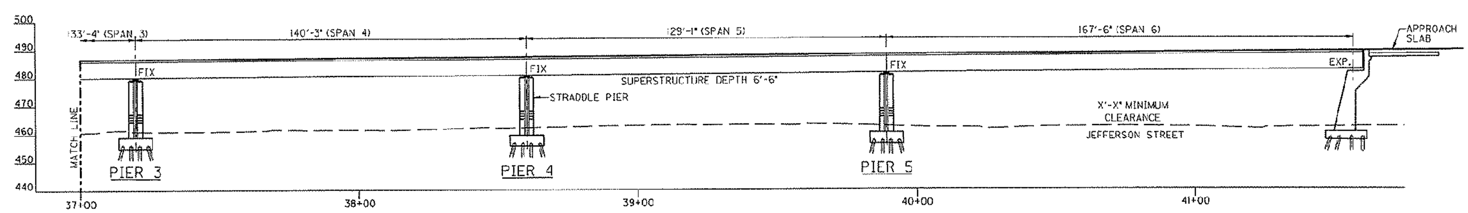
LX2005130\PHASE1\S0620\S0620_LAYO1.DGN

DATE: $$$$DATE$$$$ USERNAME: $$$$USER$$$$ FILE NAME: $$$$designfilespecification$$$$ SHEET LOCATION: E-SHEET NAME:



PLAN BRIDGE A-1

RAMP 2



SECTION ALONG PROFILE GRADE RAMP 3

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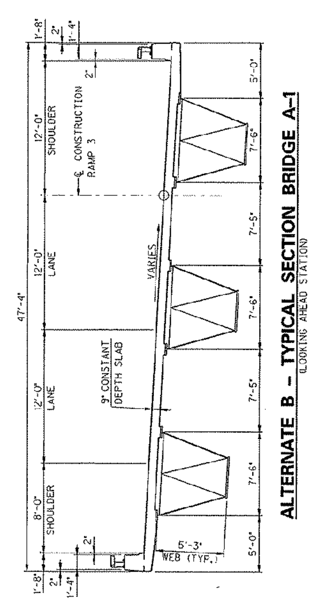
DOWNLOADED FROM
PROJECTWISE ON 6-5-06



ALTERNATE B - TYPICAL SECTION BRIDGE A-1
(LOOKING AHEAD STATION)

REVISION	DATE
DATE:	CHECKED BY
DESIGNED BY:	
DETAILED BY:	

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS
COUNTY
JEFFERSON
ROUTE
CROSSING

ITEM NUMBER

PREPARED BY
THE OHIO RIVER BRIDGES
Kentucky Transportation Associates
SHEET NO.
DRAWING NO.

LX2005130\PHASE1\S0620\S0620_LAY02.DGN

SHEET LOCATION:
FILE NAME: $$$$designs$file$$specifications$$$$
USERNAME: $$$$USER$$$$
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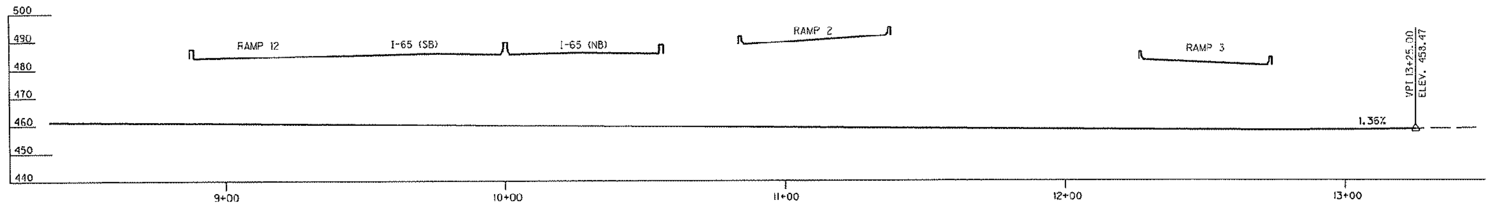
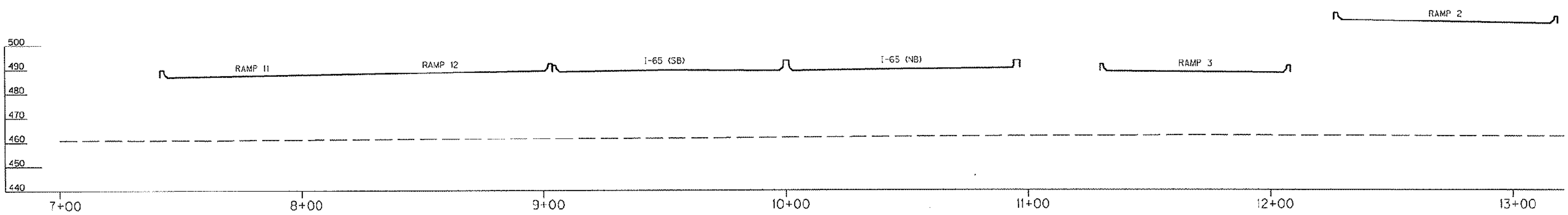
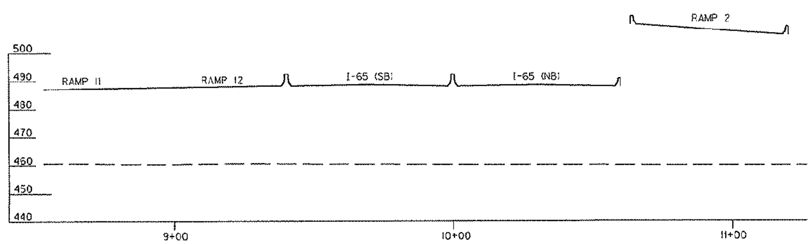


SECTION ALONG ℄ LIBERTY STREET



SECTION ALONG ℄ JEFFERSON STREET



SECTION ALONG ℄ PRESTON STREET

S0620-LAY03.DGN
DOWNLOADED FROM
PROJECTWISE ON 6-5-06

REVISION	DATE

DATE: CHECKED BY
DESIGNED BY:
DETAILED BY:

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
JEFFERSON

ROUTE **I-65** CROSSING **LIBERTY, PRESTON & JEFFERSON**

BRIDGE A-1 PROFILES

PREPARED BY
THE OHIO RIVER BRIDGES
Kentucky Transportation Associates

SHEET NO.
DRAWING NO.

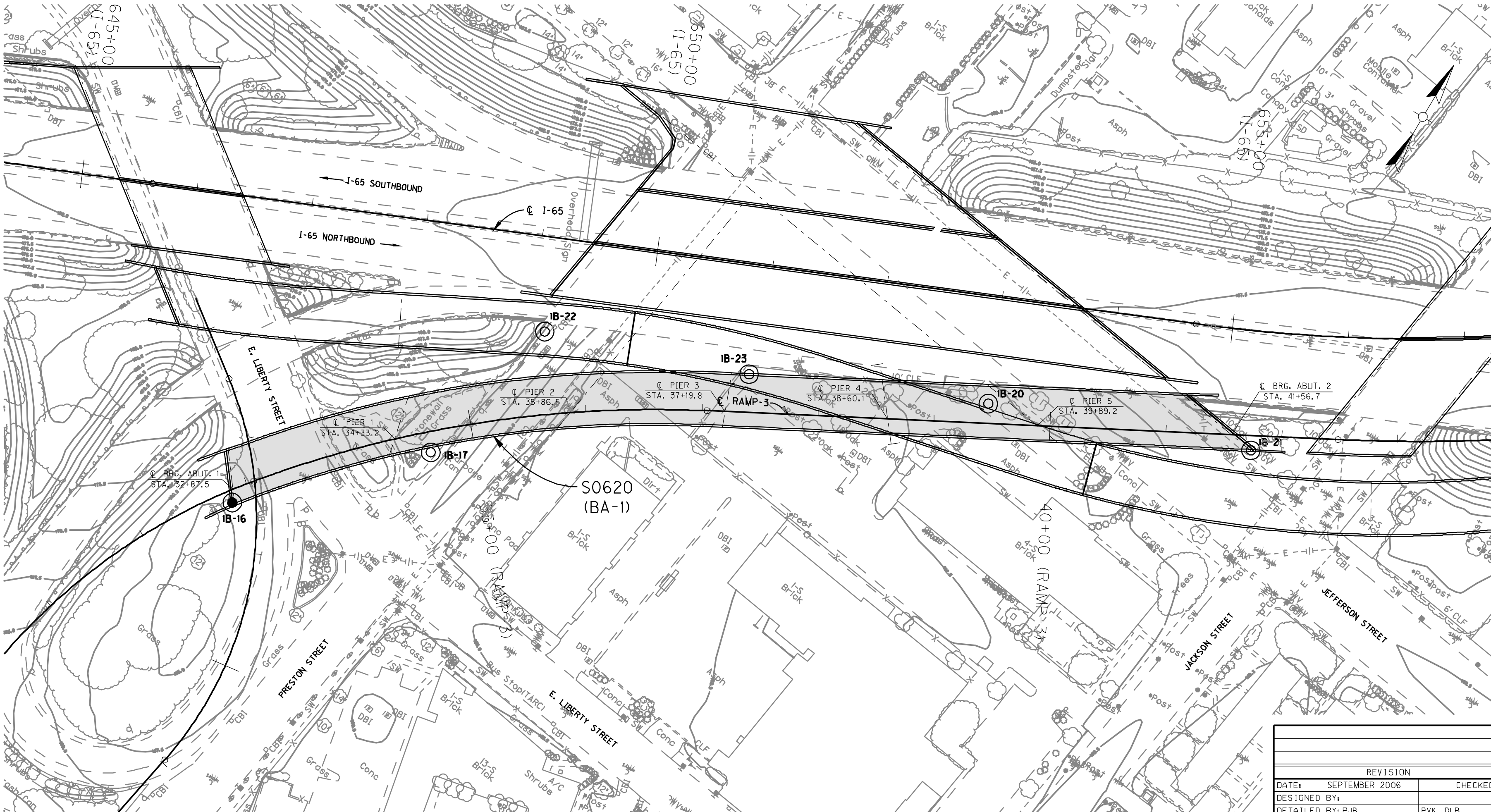
ITEM NUMBER
5-118.18 & 5-118.19

LX20051301PHASE1\S0620\S0620_LAY03.DGN

SHEET LOCATION:
FILE NAME: $$$$designfilespecification$$$$
USERNAME: $$$$USER$$$$
DATE: $$$$DATE$$$$
E-SHEET NAME:

Appendix C

Subsurface Data Sheets



BORING LAYOUT

SCALE: 1"=40'

NOTE:

The Information for the bridge layout used on this drawing was obtained through the Bentley Projectwise Program from the Kentucky Transportation Associates Design Team on June 5, 2006.

Sheet 1 of 4

LX2004130/PHASE1/S060/S0620_LAY0.DGN

REVISION		DATE
DATE: SEPTEMBER 2006	CHECKED BY	
DESIGNED BY:		
DETAILED BY: PJB	PVK, DLB	

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY **JEFFERSON**

ROUTE **I-65** CROSSING **S0620 (BA-1) BRIDGE**

BORING LAYOUT

PREPARED BY THE OHIO RIVER BRIDGES — Kentucky Transportation Associates

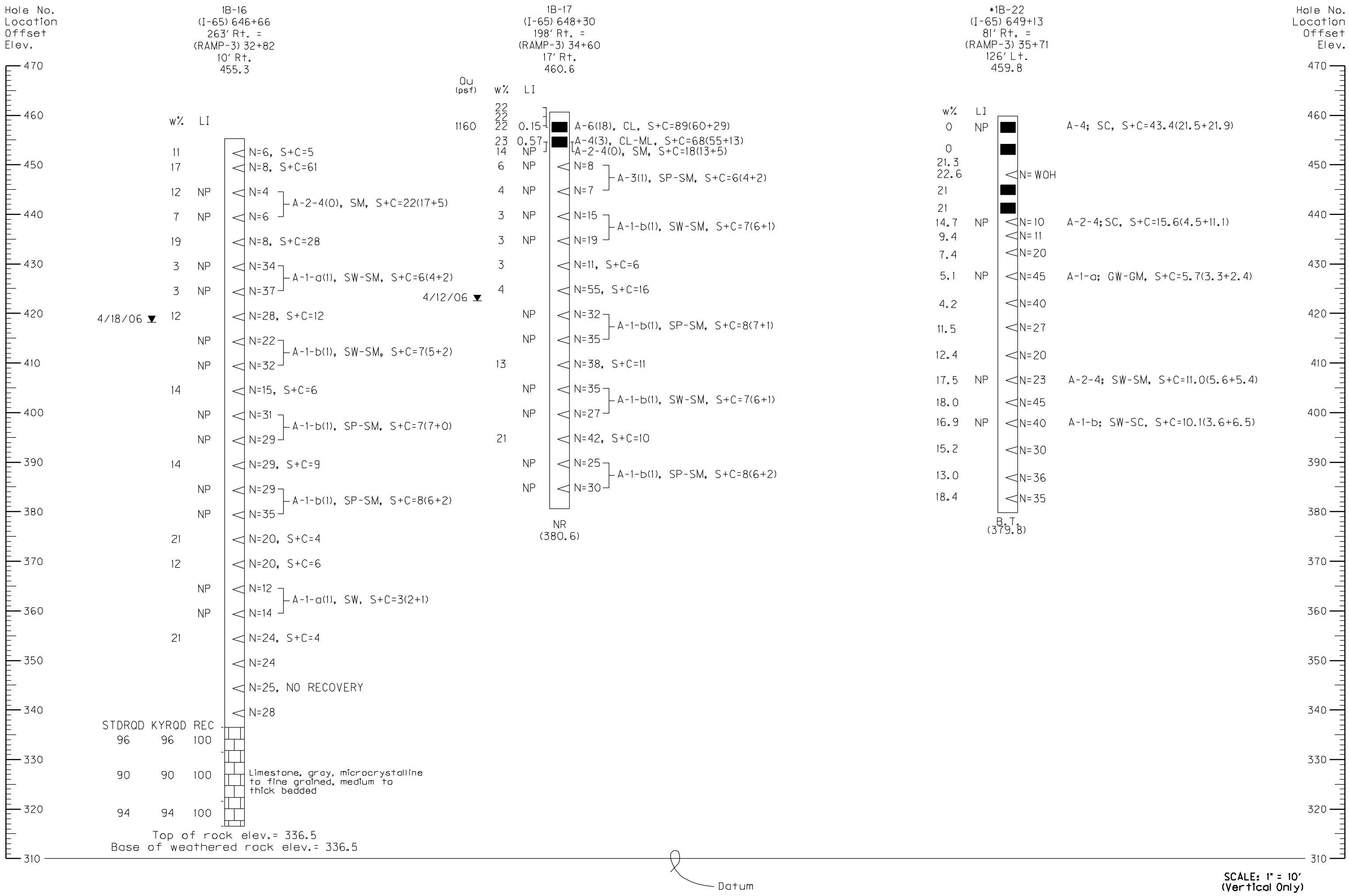
SHEET NO.

DRAWING NO.

ITEM NUMBER

5-118.18/.19

E-SHEET NAME: DATE: $$$$DATE$$$$ USERNAME: $$$$USER$$$$ FILE NAME: $$$$designs$files$specifications$$$ SHEET LOCATION:



•Hole IB-22 was drilled for S0750 (B65-5). Geotechnical Engineering services, including drafting and lab testing, are being provided by K.S. Ware and Associates. The drafted logs for this boring was provided by, K.S. Ware and Associates.

NOTES:

1. This sheet presents geotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.
3. All standard penetration testing performed for structure borings were done utilizing an automatic hammer.

LX2004130/PHASEI/S0620/S0620_LOG1.DGN

SCALE: 1" = 10'
(Vertical Only)

REVISION	DATE
DATE: SEPTEMBER 2006	CHECKED BY
DESIGNED BY:	
DETAILED BY: PJB	PVK, DLB

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
JEFFERSON

ROUTE I-65 — CROSSING S0620 (BA-1) BRIDGE

BORING LOGS

PREPARED BY
THE OHIO RIVER BRIDGES
Kentucky Transportation Associates

SHEET NO.
DRAWING NO.

ITEM NUMBER
5-118.18/.19

SHEET LOCATION:
FILE NAME: $$$$designs$files$specifications$$$
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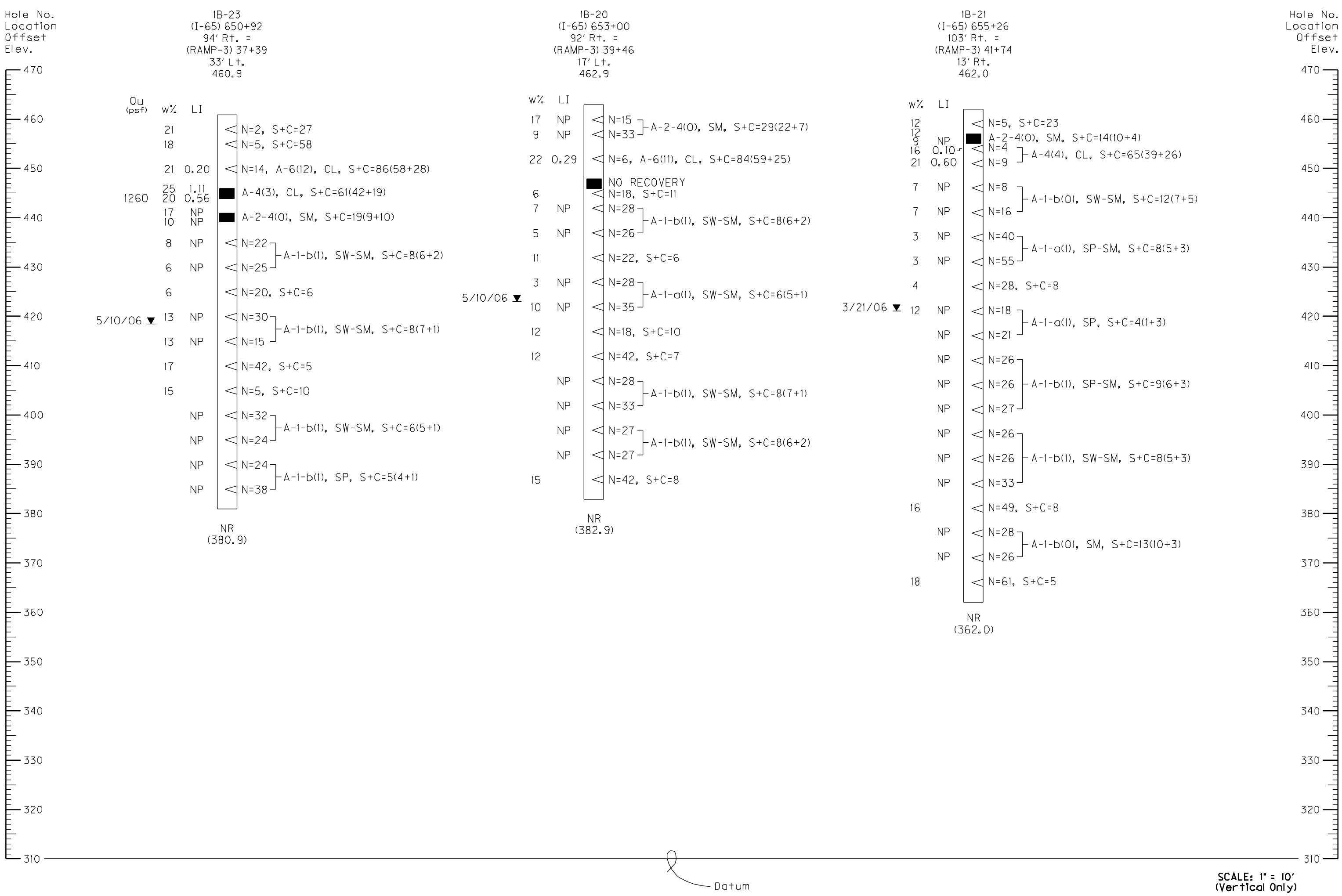


NOTES:

1. This sheet presents geotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.
3. All standard penetration testing performed for structure borings were done utilizing an automatic hammer.

SCALE: 1" = 10'
(Vertical Only)

REVISION		DATE
DATE: SEPTEMBER 2006	CHECKED BY	
DESIGNED BY:		
DETAILED BY: PJB	PVK, DLB	

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
JEFFERSON

ROUTE I-65 | CROSSING S0620 (BA-1) BRIDGE

BORING LOGS

PREPARED BY
THE OHIO RIVER BRIDGES
Kentucky Transportation Associates

SHEET NO.
DRAWING NO.

ITEM NUMBER
5-118.18/.19

Sheet 3 of 4

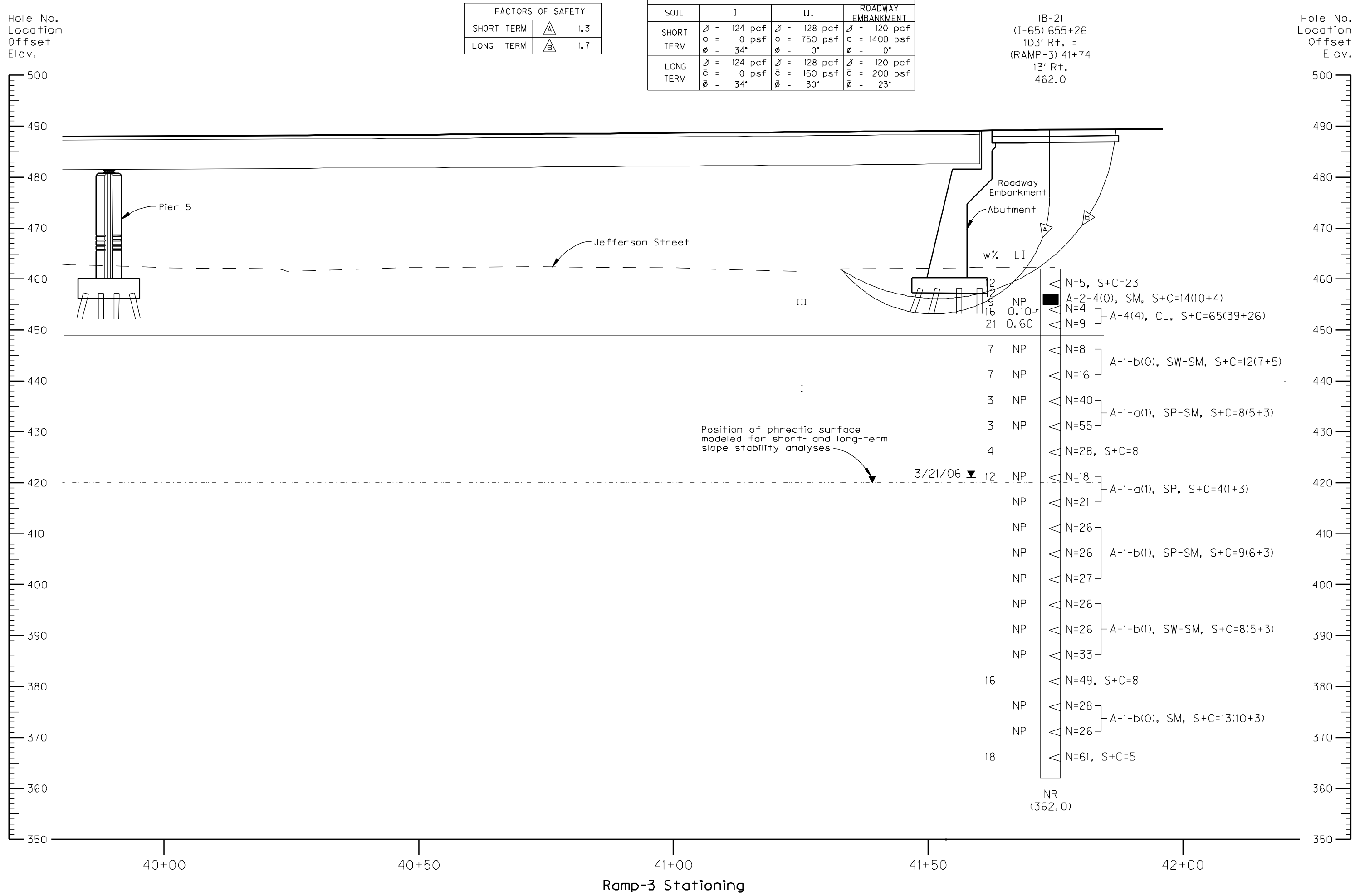
LX2004130/PHASE1/S0620/S0620_LOG2.DGN

SHEET LOCATION:
FILE NAME: $$$$designs$files$specifications$$$
USERNAME: $$$$USER$$$$
DATE: $$$$DATE$$$$
E-SHEET NAME:

FACTORS OF SAFETY		
SHORT TERM	A	1.3
LONG TERM	B	1.7

ESTIMATED SOIL STRENGTH PARAMETERS

SOIL	I	III	ROADWAY EMBANKMENT
SHORT TERM	γ = 124 pcf c = 0 psf ø = 34°	γ = 128 pcf c = 750 psf ø = 0°	γ = 120 pcf c = 1400 psf ø = 0°
LONG TERM	γ = 124 pcf c̄ = 0 psf ø̄ = 34°	γ = 128 pcf c̄ = 150 psf ø̄ = 30°	γ = 120 pcf c̄ = 200 psf ø̄ = 23°



SUMMARY OF ESTIMATED SETTLEMENT PARAMETERS	
SOIL LAYER	SETTLEMENT PARAMETERS
III	e_o = 0.519 C_c = 0.106 C_r = 0.010 P_c = 2,100 psf γ = 128 pcf
I	C' = 58 γ = 124 pcf

NOTES:

1. This sheet presents geotechnical data and recommendations. Refer to project plans, profiles, and cross sections for final alignment and grade.
2. Surface elevations are referenced to Mean Sea Level.
3. All standard penetration testing performed for structure borings were done utilizing an automatic hammer.
4. The information for the bridge elevation used on this drawing was obtained through the Bentley Projectwise Program from the Kentucky Transportation Associates Design Team on June 2, 2006.

LX2004130/PHASE1/S0620/S0620_STAB.DGN

SCALE: 1" = 10'

REVISION	DATE

DATE: SEPTEMBER 2006	CHECKED BY
DESIGNED BY:	
DETAILED BY: PJB	PVK, DLB

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
JEFFERSON

ROUTE I-65 | CROSSING S0620 (BA-1) BRIDGE

STABILITY SECTION

PREPARED BY
THE OHIO RIVER BRIDGES
Kentucky Transportation Associates

SHEET NO.
DRAWING NO.

ITEM NUMBER
5-118.18/.19

Sheet 4 of 4

SHEET LOCATION:
FILE NAME: $$$$designs$files$specifications$$$$
USERNAME: $$$$USER$$$$
DATE: $$$$DATE$$$$
E-SHEET NAME:

Appendix D

Coordinate Data Submission Form

COORDINATE DATA SUBMISSION FORM
KYTC DIVISION OF MATERIALS - GEOTECHNICAL BRANCH

County: Jefferson

Road Number: Ohio River Bridges - Phase 1

Survey Crew / Consultant: Qk4, Inc.

Contact Person: Jim Krauth

Item No.: 5-118.18/ .19

Mars No.: C-04224166

Project No.: N/A

Date: July 13, 2006

Notes: S0620 (BA-1) Muhammad Ali Boulevard to I-65 Northbound.

(select one) **Elevation Datum** **Sea Level** **Assumed**

HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)	LATITUDE	LONGITUDE
1B-16	646+66	263' Rt.	455.3	38.251248	85.747087
1B-17	648+30	198' Rt.	460.6	38.251596	85.746659
1B-22	649+13	81' Rt.	459.8	38.251980	85.746558
1B-20	653+00	92' Rt.	462.9	38.252386	85.745312
1B-21	655+26	103' Rt.	462.0	38.252618	85.744568
1B-23	650+92	94' Rt.	460.9	38.252148	85.745970

Appendix E

Correction of SPT Data

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Soil No.	Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf)	Vertical Effective Stress (tsf)	SPT N Value	SPT N Value	Correction Factor	Corrected N-Value	Relative Density (%)	Unified Soil Classification	Internal Angle of Friction (degrees)	Unit Weight Dry (pcf)	Moisture Content (%)	Revised In-situ Unit Weight (pcf)	Void Ratio
		γ_w	σ'	N_{80}	N_{60}	C_N	$(N_1)_{60}$	D_r		ϕ'	γ_d	m	γ_w	e

NOTES:

C. This spreadsheet has been designed such that an initial "Assumed Estimated Unit Weight" is placed into Column C.

E. N_{80} is the blow count per foot as determined in the field using a automatic hammer.

F. $N_{60} = (E_{AH}/60)\ N_{AH}$, where: E_{AH} = autohammer efficiency (80%): N_{AH} = blowcount from the autohammer, as referenced in (1)
The autohammer efficiency is based on typical values of efficiencies (85 - 95) and actual testing preformed on FMSM hammers. SPT Analyzer equipment from Pile Dynamics Inc. was used to conduct the testing. An autohammer is more enegry efficient than a standard hammer.
Hammer efficiency is a means of comparing the energy transferred from the hammer to the drill string during sampling.

G. Correction Factor Based on 1/(square root of vertical effective stress). (Liao, S.C. and Whitman, R.V. 1985.
"Overburden Correction Factors for SPT in Sand", JGED, ASCE, Vol. 112, No. 3, pp. 373-377; as referenced in (2).
This correction factor is limited to vertical effective stresses greater than 0.25 tsf.

I. Relative Density based on Tokimatsu, K. and Seed, H.B. 1988. "Evaluation of Settlements in Sands Due to Earthquake Shaking", JGED, ASCE, Vol. 113, No. 8, pp. 861-878; as referenced in (2).

J. Classification based on field and laboratory data by FMSM.

K, L and O Angle of Internal Friction (phi), Unit Weight Dry and Void Ratio based on NAVFAC 7.1 "Soil Mechanics", May 1982, page 7.1-149.

M. Moisture content based on laboratory testing of SPT samples by FMSM.

N. In-situ unit weight is based on dry unit weight (L) times (1 + moisture content).

(1) Goble, George, GRL Newsletter, December 1995 "SPT Improvements"

(2) Seed and Harder, Volume 2 Memorial Symposium Proceedings, May 1990. "SPT Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength", pp. 361-362.

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval	Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
				Input Required										
1B-16		water =	37.1	4/18/2006										
2.0 - 3.5	2.75	115	0.16	6	8	1.00	8	41	SM	30.5	95	10.6	105	0.76
5.0 - 6.5	5.75	115	0.33	8	11	1.00	11	47	SM	31	96	17.1	112	0.74
10.0 - 11.5	10.75	115	0.62	4	5	1.00	5	32	SM	29.5	93	11.9	104	0.8
15.0 - 16.5	15.75	115	0.91	6	8	1.00	8	41	SM	30.5	95	7.4	102	0.76
20.0 - 21.5	20.75	115	1.19	8	11	0.92	10	44	SW-SM	31.5	103	18.8	122	0.62
25.0 - 26.5	25.75	115	1.48	34	45	0.82	37	87	SW-SM	37	113	3.3	117	0.48
30.0 - 31.5	30.75	115	1.77	37	49	0.75	37	87	SW-SM	37	113	2.7	116	0.48
35.0 - 36.5	35.75	115	2.06	28	37	0.70	26	75	SW-SM	36	110	11.9	123	0.52
40.0 - 41.5	40.75	115	2.19	22	29	0.68	20	65	SW-SM	34.5	108	13.5	123	0.55
45.0 - 46.5	45.75	115	2.32	32	43	0.66	28	77	SW-SM	36	110	13.5	125	0.52
50.0 - 51.5	50.75	115	2.45	15	20	0.64	13	52	SW-SM	33	105	13.5	119	0.59
55.0 - 56.5	55.75	115	2.58	31	41	0.62	26	74	SP-SM	35	109	14.0	124	0.54
60.0 - 61.5	60.75	115	2.71	29	39	0.61	24	71	SP-SM	35	109	14.0	124	0.54
65.0 - 66.5	65.75	115	2.84	29	39	0.59	23	70	SP-SM	35	109	14.0	124	0.54
70.0 - 71.5	70.75	115	2.98	29	39	0.58	22	70	SP-SM	35	109	14.0	124	0.54
75.0 - 76.5	75.75	115	3.11	35	47	0.57	27	75	SP-SM	36	110	14.0	125	0.52
80.0 - 81.5	80.75	115	3.24	20	27	0.56	15	56	SW	34.4	113	21.0	137	0.48
85.0 - 86.5	85.75	115	3.37	20	27	0.54	15	56	SW	34.4	113	12.1	127	0.48
90.0 - 91.5	90.75	115	3.50	12	16	0.53	9	41	SW	32.3	110	21.2	133	0.52
95.0 - 96.5	95.75	115	3.63	14	19	0.52	10	44	SW	32.3	110	21.2	133	0.52
100.0 - 101.5	100.75	115	3.77	24	32	0.52	17	60	SW	35	114	21.2	138	0.46
105.0 - 106.5	105.75	115	3.90	24	32	0.51	16	60	SW	35	114	21.2	138	0.46
110.0 - 111.5	110.75	115	4.03	25	33	0.50	17	60	No Recovery	NA	NA	21.2	NA	NA
115.0 - 116.5	115.75	115	4.16	28	37	0.49	18	63	SW	35	114	21.2	138	0.46

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval	Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
				Input Required										
1B-17		water =	38.1	4/12/2006										
2.0 - 4.0	3.00	115	0.17	ST	NA	1.00	NA	#N/A	CL	NA	NA	22.3	NA	NA
5.0 - 7.0	6.00	115	0.35	ST	NA	1.00	NA	#N/A	CL-ML / SM	NA	NA	6.0	NA	NA
10.0 - 11.5	10.75	115	0.62	8	11	1.00	11	47	SP-SM	32	104	5.9	110	0.61
15.0 - 16.5	15.75	115	0.91	7	9	1.00	9	44	SP-SM	31.5	103	4.2	107	0.62
20.0 - 21.5	20.75	115	1.19	15	20	0.92	18	63	SW-SM	34	107	3.1	110	0.56
25.0 - 26.5	25.75	115	1.48	19	25	0.82	21	67	SW-SM	34.5	108	2.6	111	0.55
30.0 - 31.5	30.75	115	1.77	11	15	0.75	11	47	SW-SM	32	104	3.2	107	0.61
35.0 - 36.5	35.75	115	2.06	55	73	0.70	51	98	SP-SM	38.5	115	3.6	119	0.45
40.0 - 41.5	40.75	115	2.19	32	43	0.68	29	77	SP-SM	36	110	12.8	124	0.52
45.0 - 46.5	45.75	115	2.32	35	47	0.66	31	79	SP-SM	36	110	12.8	124	0.52
50.0 - 51.5	50.75	115	2.45	38	51	0.64	32	82	SP-SM	36.5	111.5	12.8	126	0.5
55.0 - 56.5	55.75	115	2.58	35	47	0.62	29	79	SW-SM	36	110	12.8	124	0.52
60.0 - 61.5	60.75	115	2.71	27	36	0.61	22	68	SW-SM	34.5	108	12.8	122	0.55
65.0 - 66.5	65.75	115	2.84	42	56	0.59	33	84	SW-SM	36.5	111.5	21.1	135	0.5
70.0 - 71.5	70.75	115	2.98	25	33	0.58	19	65	SP-SM	34.5	108	21.1	131	0.55
75.0 - 76.5	75.75	115	3.11	30	40	0.57	23	70	SP-SM	35	109	21.1	132	0.54

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval	Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
				Input Required										
									Class. Estimated					
1B-22		water =	37.9	4/12/2006					based on boring log					
2.0 - 4.0	3.00	115	0.17	ST	NA	1.00	NA	#N/A	SM	#N/A	#N/A		#N/A	#N/A
5.0 - 7.0	6.00	115	0.35	ST	NA	1.00	NA	#N/A	SM	#N/A	#N/A		#N/A	#N/A
7.0 - 8.5	7.75	115	0.45	0	0	1.00	1	11	SM	27.5	89.5		90	0.87
10.0 - 11.5	10.75	115	0.62	ST	NA	1.00	NA	#N/A	CL	NA	NA		NA	NA
15.0 - 15.8	15.4	115	0.89	ST	NA	1.00	NA	#N/A	CL	NA	NA		NA	NA
15.8 - 17.3	16.55	115	0.95	10	13	1.00	13	53	SW-SM	33	105		105	0.59
20.0 - 21.5	20.75	115	1.19	11	15	0.92	13	53	SW-SM	33	105		105	0.59
25.0 - 26.5	25.75	115	1.48	20	27	0.82	22	68	SW-SM	34.5	108		108	0.55
30.0 - 31.5	30.75	115	1.77	45	60	0.75	45	93	SW-SM	38	114		114	0.47
35.0 - 36.5	35.75	115	2.06	40	53	0.70	37	87	SW-SM	37	113		113	0.48
40.0 - 41.5	40.75	115	2.19	27	36	0.68	24	73	SW-SM	35	109		109	0.54
45.0 - 46.5	45.75	115	2.32	20	27	0.66	18	60	SW-SM	34	107		107	0.56
50.0 - 51.5	50.75	115	2.45	23	31	0.64	20	65	SW-SM	34.5	108		108	0.55
55.0 - 56.5	55.75	115	2.58	45	60	0.62	37	87	SW-SM	37	113		113	0.48
60.0 - 61.5	60.75	115	2.71	40	53	0.61	32	82	SW-SM	36.5	111.5		112	0.5
65.0 - 66.5	65.75	115	2.84	30	40	0.59	24	71	SW-SM	35	109		109	0.54
70.0 - 71.5	70.75	115	2.98	36	48	0.58	28	77	SW-SM	36	110		110	0.52
75.0 - 76.5	75.75	115	3.11	35	47	0.57	27	75	SW-SM	36	110		110	0.52

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval		Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf)	Vertical Effective Stress (tsf)	SPT N Value	SPT N Value	Correction Factor	Corrected N-Value	Relative Density (%)	Unified Soil Classification	Internal Angle of Friction (degrees)	Unit Weight Dry (pcf)	Moisture Content (%)	Revised In-situ Unit Weight (pcf)	Void Ratio
			γ_w	σ'	N_{80}	N_{60}	C_N	$(N_1)_{60}$	D_r		ϕ'	γ_d	m	γ_w	e
					Input Required										
1B-23			water =	42.5	5/10/2006										
2.0 -	3.5	2.75	115	0.16	2	3	1.00	3	18	CL	NA	NA	20.8	NA	NA
5.0 -	6.5	5.75	115	0.33	5	7	1.00	7	35	CL	NA	NA	17.7	NA	NA
10.0 -	11.5	10.75	115	0.62	14	19	1.00	19	63	CL	NA	NA	20.7	NA	NA
15.0 -	17.0	16	115	0.92	ST	NA	1.00	NA	#N/A	CL	NA	NA	20.0	NA	NA
20.0 -	21.7	20.85	115	1.20	ST	NA	0.91	NA	#N/A	SM	#N/A	#N/A	20.0	#N/A	#N/A
25.0 -	26.5	25.75	115	1.48	22	29	0.82	24	73	SW-SM	35	109	8.2	118	0.54
30.0 -	31.5	30.75	115	1.77	25	33	0.75	25	74	SW-SM	35	109	6.0	116	0.54
35.0 -	36.5	35.75	115	2.06	20	27	0.70	19	63	SW-SM	34	107	6.1	114	0.56
40.0 -	41.5	40.75	115	2.34	30	40	0.65	26	75	SW-SM	36	110	12.6	124	0.52
45.0 -	46.5	45.75	115	2.47	15	20	0.64	13	52	SW-SM	33	105	12.7	118	0.59
50.0 -	51.5	50.75	115	2.61	42	56	0.62	35	84	SW-SM	36.5	111.5	16.8	130	0.5
55.0 -	56.5	55.75	115	2.74	5	7	0.60	4	27	SW-SM	29.5	99.5	15.1	115	0.68
60.0 -	61.5	60.75	115	2.87	32	43	0.59	25	74	SW-SM	35	109	15.1	125	0.54
65.0 -	66.5	65.75	115	3.00	24	32	0.58	19	63	SW-SM	34	107	15.1	123	0.56
70.0 -	71.5	70.75	115	3.13	24	32	0.57	18	63	SP	35	114	15.1	131	0.46
75.0 -	76.5	75.75	115	3.26	38	51	0.55	28	77	SP	37	117.5	15.1	135	0.42

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval		Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf)	Vertical Effective Stress (tsf)	SPT N Value	SPT N Value	Correction Factor	Corrected N-Value	Relative Density (%)	Unified Soil Classification	Internal Angle of Friction (degrees)	Unit Weight Dry (pcf)	Moisture Content (%)	Revised In-situ Unit Weight (pcf)	Void Ratio
			γ_w	σ'	N_{80}	N_{60}	C_N	$(N_1)_{60}$	D_r		ϕ'	γ_d	m	γ_w	e
					Input Required										
1B-20			water =	38.9	5/10/2006										
2.0 -	3.5	2.75	115	0.16	15	20	1.00	20	67	SM	33.5	100	16.8	117	0.67
5.0 -	6.5	5.75	115	0.33	33	44	1.00	44	93	SM	36.5	106	9.1	116	0.58
10.0 -	11.5	10.75	115	0.62	6	8	1.00	8	41	CL	NA	NA	22.3	NA	NA
15.0 -	17.0	16	115	0.92	ST	NA	1.00	NA	#N/A	No Recovery	NA	NA		NA	NA
17.0 -	18.5	17.75	115	1.02	18	24	0.99	24	71	SW-SM	35	109	6.3	116	0.54
20.0 -	21.5	20.75	115	1.19	28	37	0.92	34	84	SW-SM	36.5	111.5	7.3	120	0.5
25.0 -	26.5	25.75	115	1.48	26	35	0.82	29	77	SW-SM	36	110	4.7	115	0.52
30.0 -	31.5	30.75	115	1.77	22	29	0.75	22	70	SW-SM	35	109	10.8	121	0.54
35.0 -	36.5	35.75	115	2.06	28	37	0.70	26	75	SW-SM	36	110	3.3	114	0.52
40.0 -	41.5	40.75	115	2.19	35	47	0.68	32	81	SW-SM	36.5	111.5	9.5	122	0.5
45.0 -	46.5	45.75	115	2.32	18	24	0.66	16	58	SW-SM	33.5	106	11.7	118	0.57
50.0 -	51.5	50.75	115	2.45	42	56	0.64	36	86	SW-SM	37	113	11.9	126	0.48
55.0 -	56.5	55.75	115	2.58	28	37	0.62	23	71	SW-SM	35	109	14.5	125	0.54
60.0 -	61.5	60.75	115	2.71	33	44	0.61	27	75	SW-SM	36	110	14.5	126	0.52
65.0 -	66.5	65.75	115	2.84	27	36	0.59	21	68	SW-SM	34.5	108	14.5	124	0.55
70.0 -	71.5	70.75	115	2.98	27	36	0.58	21	67	SW-SM	34.5	108	14.5	124	0.55
75.0 -	76.5	75.75	115	3.11	42	56	0.57	32	81	SW-SM	36.5	111.5	14.5	128	0.5

KENNEDY INTERCHANGE
CORRELATION OF SPT DATA TO UNIT WEIGHTS AND SHEAR STRENGTHS
FOR COARSE GRAINED SOILS

Sample Interval	Depth of Mid. Pt. of Sample (ft.)	Assumed Estimated Unit Weight (pcf) γ_w	Vertical Effective Stress (tsf) σ'	SPT N Value N_{80}	SPT N Value N_{60}	Correction Factor C_N	Corrected N-Value $(N_1)_{60}$	Relative Density (%) D_r	Unified Soil Classification	Internal Angle of Friction (degrees) ϕ'	Unit Weight Dry (pcf) γ_d	Moisture Content (%) m	Revised In-situ Unit Weight (pcf) γ_w	Void Ratio e
				Input Required										
1B-21		water =	40.9	3/21/2006										
2.0 - 3.5	2.75	115	0.16	5	7	1.00	7	35	SM	30	94	12.2	105	0.78
5.0 - 7.0	6	115	0.35	ST	NA	1.00	NA	#N/A	SM	#N/A	#N/A	10.5	#N/A	#N/A
7.0 - 8.5	7.75	115	0.45	4	5	1.00	5	32	CL	NA	NA	16.0	NA	NA
10.0 - 11.5	10.75	115	0.62	9	12	1.00	12	52	CL	NA	NA	20.8	NA	NA
15.0 - 16.5	15.75	115	0.91	8	11	1.00	11	47	SW-SM	32	104	6.9	111	0.61
20.0 - 21.5	20.75	115	1.19	16	21	0.92	20	65	SW-SM	34.5	108	6.8	115	0.55
25.0 - 26.5	25.75	115	1.48	40	53	0.82	44	91	SP-SM	38	114	3.4	118	0.47
30.0 - 31.5	30.75	115	1.77	55	73	0.75	55	100	SP-SM	39	116	3.0	119	0.44
35.0 - 36.5	35.75	115	2.06	28	37	0.70	26	75	SP-SM	36	110	3.8	114	0.52
40.0 - 41.5	40.75	115	2.34	18	24	0.65	16	58	SP	34.4	113	12.2	127	0.48
45.0 - 46.5	45.75	115	2.47	21	28	0.64	18	60	SP	35	114	12.2	128	0.46
50.0 - 51.5	50.75	115	2.61	26	35	0.62	22	68	SP-SM	34.5	108	16.4	126	0.55
55.0 - 56.5	55.75	115	2.74	26	35	0.60	21	68	SP-SM	34.5	108	16.4	126	0.55
60.0 - 61.5	60.75	115	2.87	27	36	0.59	21	68	SP-SM	34.5	108	16.4	126	0.55
65.0 - 66.5	65.75	115	3.00	26	35	0.58	20	67	SW-SM	34.5	108	16.4	126	0.55
70.0 - 71.5	70.75	115	3.13	26	35	0.57	20	65	SW-SM	34.5	108	16.4	126	0.55
75.0 - 76.5	75.75	115	3.26	33	44	0.55	24	73	SW-SM	35	109	16.4	127	0.54
80.0 - 81.5	80.75	115	3.40	49	65	0.54	36	86	SW-SM	37	113	16.4	132	0.48
85.0 - 86.5	85.75	115	3.53	38	51	0.53	27	77	SM	34.5	102	16.4	119	0.63
90.0 - 91.5	90.75	115	3.66	26	35	0.52	18	63	SM	33	99	16.4	115	0.69
95.0 - 96.5	95.75	115	3.79	61	81	0.51	42	91	SM	36.5	106	18.2	125	0.58

Appendix F

Idealized Soil Profiles

SOIL PROFILE LEGEND SHEET

Kennedy Interchange
Bridge S0620 (BA-1)

SUMMARY OF PARAMETERS DEVELOPED FOR SOIL AND BEDROCK PROFILES

Parameter	Units	Description and Reference
γ_t	lb/ft^3	Total Unit Weight
γ_e	lb/ft^3	Effective Unit Weight
q_u	ton/ft^2	Uniaxial Compressive Strength (either soil or rock)
c_u	ton/ft^2	Undrained Shear Strength (either soil or rock)
ϕ	(°)	Angle of Internal Friction
k_s	lb/in^3 (soil)	Secant Modulus {computer program LPILEPLUS}
$\mathbf{E_{50}}$	lb/in^2	Strain, {Value of strain at 50% of the maximum stress}

SOIL PROFILE

Kennedy Interchange
Bridge S0620 (BA-1)
Abutment 1
(Based on Hole 1B-16)

Approximate Elevations (ft)	Approximate Depths (ft)	STRATA Description	Parameters	
455.3	0.0			
		Silt and Sand with gravel (SM and SW-SM)	γ_t (lb/ft^3) = 109.0 γ_e (lb/ft^3)* = 46.6 ϕ (^{o}) = 31.0 k_s (lb/in^3) = 25.0	
				P-Y Curve Reference Number 4
432.1	23.2			
		Sitly Sand with Gravel (SW-SM, SP, and SP-SM)	γ_t (lb/ft^3) = 124.0 γ_e (lb/ft^3)* = 61.6 ϕ (^{o}) = 34.0 k_s (lb/in^3) = 25.0	(above water table)
420.0	∇		k_s (lb/in^3) = 60.0	(below water table)
				P-Y Curve Reference Number 4
336.5*	120.0	No Refusal		
		Boring Terminated		

* Top of Rock

SOIL PROFILE

Kennedy Interchange
Bridge S0620 (BA-1)
Pier 1
(Based on Holes 1B-16 and 1B-17)

Approximate Elevations (ft)	Approximate Depths (ft)	STRATA Description	Parameters	
455.3 - 460.6	0.0			
		Lean Clay with Silt and Sand (CL-ML, and CL)	γ_t (lb/ft^3) = 128.0 c_u (tsf) = 0.38 k_s (lb/in^3) = 500.0 E_{50} = 0.005	
				P-Y Curve Reference Number 3
455.3-454.6	0.0-6.0			
		Silt and Sand with gravel (SM and SP-SM and SW-SM)	γ_t (lb/ft^3) = 109.0 γ_e (lb/ft^3)* = 46.6 ϕ (^{o}) = 31.0 k_s (lb/in^3) = 25.0	
				P-Y Curve Reference Number 4
432.1-427.4	23.2-33.2			
		Sitly Sand with Gravel (SW-SM, SP-SM, SW, & SP)	γ_t (lb/ft^3) = 124.0 γ_e (lb/ft^3)* = 61.6 ϕ (^{o}) = 34.0 k_s (lb/in^3) = 90.0 k_s (lb/in^3) = 60.0	 (above water table) (below water table)
420.0	∇			
				P-Y Curve Reference Number 4
336.5-380.6	118.8 - 80.0	No Refusal		
		Boring Terminated		

Note: A range in elevation and depths are being provided because of t
variance between applicable borings

SOIL PROFILE

Kennedy Interchange
Bridge S0620 (BA-1)
Pier 2
(Based on Holes 1B-17 and 1B-23)

Approximate Elevations (ft)	Approximate Depths (ft)	STRATA Description	Parameters	
460.6-460.9	0.0			
		Lean Clay with Silt and Sand (CL-ML, and CL)	γ_t (lb/ft^3) = 128.0 c_u (tsf) = 0.38 k_s (lb/in^3) = 500.0 E_{50} = 0.005	
				P-Y Curve Reference Number 3
454.6-442.4	6.0-18.5			
		Silt and Sand with gravel (SM and SP-SM and SW-SM)	γ_t (lb/ft^3) = 109.0 γ_e (lb/ft^3)* = 46.6 ϕ (^{o}) = 31.0 k_s (lb/in^3) = 25.0	
				P-Y Curve Reference Number 4
424.4-442.4	36.2-18.5			
		Sitly Sand with Gravel (SW-SM, SP-SM, SW, & SP)	γ_t (lb/ft^3) = 124.0 γ_e (lb/ft^3)* = 61.6 ϕ (^{o}) = 34.0 k_s (lb/in^3) = 90.0 (above water table)	
420.0	▽		k_s (lb/in^3) = 60.0 (below water table)	
				P-Y Curve Reference Number 4
380.6-380.9	80.0	No Refusal		
		Boring Terminated		

Note: A range in elevation and depths are being provided because of t
variance between applicable borings

SOIL PROFILE

Kennedy Interchange
Bridge S0620 (BA-1)
Pier 3
(Based on Holes 1B-17 and 1B-23)

Approximate Elevations (ft)	Approximate Depths (ft)	STRATA Description	Parameters		
460.6-460.9	0.0				
		Lean Clay with Silt and Sand (CL-ML, and CL)	γ_t (lb/ft^3) = 128.0 c_u (tsf) = 0.38 k_s (lb/in^3) = 500.0 E_{50} = 0.005		
					P-Y Curve Reference Number 3
454.6-442.4	6.0-18.5				
		Silt and Sand with gravel (SM and SP-SM and SW-SM)	γ_t (lb/ft^3) = 109.0 γ_e (lb/ft^3)* = 46.6 ϕ (^{o}) = 31.0 k_s (lb/in^3) = 25.0		
					P-Y Curve Reference Number 4
424.4-442.4	36.2-18.5				
		Sitly Sand with Gravel (SW-SM, SP-SM, SW, & SP)	γ_t (lb/ft^3) = 124.0 γ_e (lb/ft^3)* = 61.6 ϕ (^{o}) = 34.0		
			k_s (lb/in^3) = 90.0	(above water table)	
420.0	▽		k_s (lb/in^3) = 60.0	(below water table)	
					P-Y Curve Reference Number 4
380.6-380.9	80.0	No Refusal			
		Boring Terminated			

Note: A range in elevation and depths are being provided because of t
variance between applicable borings

SOIL PROFILE

Kennedy Interchange
Bridge S0620 (BA-1)
Pier 4
(Based on Holes 1B-23 and 1B-20)

Approximate Elevations (ft)	Approximate Depths (ft)	STRATA Description	Parameters	
460.9-462.9	0.0			
		Lean Clay with Silt and Sand (CL-ML, and CL)	γ_t (lb/ft^3) = 128.0 c_u (tsf) = 0.38 k_s (lb/in^3) = 500.0 E_{50} = 0.005	
				P-Y Curve Reference Number 3
442.4-449.7	18.5-132.2			
		Sitly Sand with Gravel (SW-SM, SP-SM, SW, & SP)	γ_t (lb/ft^3) = 124.0 γ_e (lb/ft^3)* = 61.6 ϕ (^{o}) = 34.0 k_s (lb/in^3) = 90.0 (above water table) k_s (lb/in^3) = 60.0 (below water table)	
420.0	∇			
				P-Y Curve Reference Number 4
380.9-382.9	80.0	No Refusal		
		Boring Terminated		

Note: A range in elevation and depths are being provided because of t
variance between applicable borings

SOIL PROFILE

Kennedy Interchange
Bridge S0620 (BA-1)
Pier 5
(Based on Holes 1B-20 and 1B-21)

Approximate Elevations (ft)	Approximate Depths (ft)	STRATA Description	Parameters	
462.9-462.0	0.0			
		Lean Clay with Silt and Sand (CL-ML, and CL)	γ_t (lb/ft^3) = 128.0 c_u (tsf) = 0.38 k_s (lb/in^3) = 500.0 E_{50} = 0.005	
				P-Y Curve Reference Number 3
449.7-448.8	13.2 - 13.2			
		Sitly Sand with Gravel (SW-SM, SP-SM, SW, & SP)	γ_t (lb/ft^3) = 124.0 γ_e (lb/ft^3)* = 61.6 ϕ (^{o}) = 34.0 k_s (lb/in^3) = 90.0 k_s (lb/in^3) = 60.0	 (above water table) (below water table)
420.0	▽			
				P-Y Curve Reference Number 4
382.9-362.0	80.0-100.0	No Refusal		
		Boring Terminated		

Note: A range in elevation and depths are being provided because of t
variance between applicable borings

SOIL PROFILE

Kennedy Interchange
Bridge S0620 (BA-1)
Abutment 2
(Based on Hole 1B-21)

Approximate Elevations (ft)	Approximate Depths (ft)	STRATA Description	Parameters	
462.0	0.0			
		Lean Clay with Silt and Sand (CL, and SM)	γ_t (lb/ft^3) = 128.0 c_u (tsf) = 0.38 k_s (lb/in^3) = 500.0 E_{50} = 0.005	
				P-Y Curve Reference Number 3
448.8	13.2			
		Sitly Sand with Gravel (SW-SM, GW-GM, SW, and SP)	γ_t (lb/ft^3) = 125.0 γ_e (lb/ft^3)* = 62.6 ϕ (^{o}) = 34.0 k_s (lb/in^3) = 90.0 k_s (lb/in^3) = 60.0	 (above water table) (below water table)
420.0	∇			
				P-Y Curve Reference Number 4
362.0	100.0	No Refusal		
		Boring Terminated		

P-Y Curve Reference Numbers

1. **Soft Clay with Free Water**. Matlock, H. "Correlations for Design of Laterally Loaded Piles in Soft Clay", *Proceedings*, Offshore Technology Conference, Houston, Texas, 1970, Volume 1, Paper No. 1204, pp. 577-594.

2. **Stiff Clay with Free Water**. Reese, L.C., W.R. Cox, and F.D. Koop, "Field Testing and Analysis of Laterally Loaded Piles in Stiff Clay", *Proceedings*, Offshore Technology Conference, Houston, Texas, Paper No. 2312, 1975, pp. 671-690.

3. **Stiff Clay without Free Water**. Dunnavant, T.W., and M.W. O'Neill, "Performance, Analysis, and Interpretation of a Lateral Load Test of a 72-Inch-Diameter Bored Pile in Over-Consolidated Clay", Department of Civil Engineering, University of Houston-University Park, Houston, Texas, Report No. UHCE 85-4, September, 1985, 57 pages.

4. **Sand Above and Below the Water Table.** Cox, W.R., L.C. Reese, and B.R. Grubbs, "Field Testing of Laterally Loaded Piles in Sand", *Proceedings*, Offshore Technology Conference, Houston, Texas, Volume II, Paper No. 2079, 1974, pp. 459-472.

   American Petroleum Institute, *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms, API Recommended Practice 2A (RP 2A),* Seventeenth Edition, April 1, 1987.

5. **Soil with Both c and ϕ**. Evans, L.T., and J.M. Duncan, "Simplified Analysis of Laterally Loaded Piles", Report No. UCB/GT/82-04, Geotechnical Engineering, Department of Civil Engineering, University of California, Berkeley, 1982.

6. **Vuggy Limestone (Strong Rock)**. Reese, L.C. and K.J. Nyman, "Field Load Test of Instrumented Drilled Shafts at Islamorada, Florida", a report to Girdler Foundation and Exploration Corporation, Clearwater, Florida, February 28, 1978 (unpublished).

Appendix G

Single Shaft/Pile Capacity Estimates for Abutment 1 and Abutment 2

Resistance Factors for LRFD*

Driven Piles

	Analysis Methodology	Φ
Axial Capacity		
Skin Friction and End Bearing in Clays	α-Method	0.35
Skin Friction and End Bearing in Sands	Nordlund/Thurman Method	0.45
Uplift Resistance		
Clays	α-Method	0.25
Sands	Nordlund Method	0.35
Axial Capacity - Dynamic Analysis		
Driving Criteria established by dynamic test with signal matching at the beginning of redrive conditions only of at least one production pile per pier, but no less than the number of tests per site provided in Table 10.5.5.2.3-3. Quality control of remaining piles by calibrated wave equation and/or dynamic testing		0.65

Drilled Shafts

Resistance Mechanism	Analysis Methodology	Φ
Axial Capacity		
Side Resistance in Clays	α-Method	0.45
End Bearing in Clays	Total Stress	0.40
Side Resistance in Sands	β-Method	0.55
End Bearing in Sands	SPT Method	0.50
Uplift Resistance		
Clays	α-method	0.35
Sands	β-Method	0.45

* Resistance Factors from AASHTO LRFD Bridge Design Specifications, 3rd Edition (Including 2005 and 2006 Interim Updates), Pages 10-41 for Driven Piles and 10-45 for Drilled Shafts

Steel H-Pile Capacities

Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2

12x53 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 100 ton pile capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
	1	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.62	0.3
	2	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	1.24	0.6
	3	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	1.85	0.9
	4	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	2.47	1.2
	5	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	3.09	1.5
	6	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	3.71	1.9
	7	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	4.33	2.2
	8	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	4.94	2.5
Clay	8.4	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	5.19	2.6
Sand	8.4	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	5.19	2.6
	9	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	5.99	3.0
	10	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	7.32	3.7
Contributes to Downdrag	11	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	8.65	4.3
	12	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	9.98	5.0
	13	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	11.31	5.7
	14	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	12.64	6.3
	15	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	13.97	7.0
	16	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	15.30	7.7
	17	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	16.63	8.3
	18	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	18.35	9.2
	19	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	20.34	10.2
	20	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	22.33	11.2
	21	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	24.32	12.2
	22	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	26.30	13.2
	23	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	28.29	14.1
	24	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	30.28	15.1
	25	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	32.27	16.1
	26	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	34.25	17.1
	27	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	36.63	18.3
	28	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	39.27	19.6
	29	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	41.92	21.0
	30	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	44.56	22.3
	31	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	47.21	23.6
	31.6	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	48.79	24.4
	32	3.02	7.91	10.93	5.5	4.92	2.5	7.10	3.6	49.85	24.9
	33	10.57	7.91	18.48	9.2	8.32	4.2	12.01	6.0	52.49	26.2
	34	18.13	7.91	26.04	13.0	11.72	5.9	16.92	8.5	55.14	27.6
	35	25.68	7.91	33.59	16.8	15.12	7.6	21.84	10.9	57.78	28.9
	36	33.90	7.91	41.81	20.9	18.81	9.4	27.18	13.6	60.66	30.3
@37.2'	37	42.58	7.91	50.49	25.2	22.72	11.4	32.82	16.4	63.70	31.8
	38	51.78	7.91	59.69	29.8	26.86	13.4	38.80	19.4	66.92	33.5
	39	61.12	7.91	69.03	34.5	31.06	15.5	44.87	22.4	70.18	35.1

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
12x53 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 100 ton pile capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
Sand	40	70.45	7.91	78.36	39.2	35.26	17.6	50.93	25.5	73.45	36.7
	41	79.78	7.91	87.69	43.8	39.46	19.7	57.00	28.5	76.72	38.4
	42	89.12	7.91	97.03	48.5	43.66	21.8	63.07	31.5	79.98	40.0
	43	98.45	7.91	106.36	53.2	47.86	23.9	69.13	34.6	83.25	41.6
	44	107.78	7.91	115.69	57.8	52.06	26.0	75.20	37.6	86.52	43.3
	45	117.12	7.91	125.03	62.5	56.26	28.1	81.27	40.6	89.78	44.9
	46	126.45	7.91	134.36	67.2	60.46	30.2	87.33	43.7	93.05	46.5
	47	136.52	7.91	144.43	72.2	64.99	32.5	93.88	46.9	96.57	48.3
	48	146.79	7.91	154.70	77.3	69.61	34.8	100.55	50.3	100.17	50.1
	49	157.05	7.91	164.96	82.5	74.23	37.1	107.23	53.6	103.76	51.9
	50	167.32	7.91	175.23	87.6	78.85	39.4	113.90	56.9	107.35	53.7
	51	177.59	7.91	185.50	92.7	83.47	41.7	120.57	60.3	110.95	55.5
	52	187.85	7.91	195.76	97.9	88.09	44.0	127.25	63.6	114.54	57.3
	53	198.12	7.91	206.03	103.0	92.71	46.4	133.92	67.0	118.13	59.1
	54	208.39	7.91	216.30	108.1	97.33	48.7	140.59	70.3	121.73	60.9
	55	218.65	7.91	226.56	113.3	101.95	51.0	147.27	73.6	125.32	62.7
	56	229.66	7.91	237.57	118.8	106.90	53.5	154.42	77.2	129.17	64.6
	57	240.85	7.91	248.76	124.4	111.94	56.0	161.70	80.8	133.09	66.5
	58	252.05	7.91	259.96	130.0	116.98	58.5	168.98	84.5	137.01	68.5
	59	263.25	7.91	271.16	135.6	122.02	61.0	176.25	88.1	140.93	70.5
	60	274.45	7.91	282.36	141.2	127.06	63.5	183.53	91.8	144.85	72.4
	61	285.65	7.91	293.56	146.8	132.10	66.0	190.81	95.4	148.77	74.4
	62	296.84	7.91	304.75	152.4	137.14	68.6	198.09	99.0	152.69	76.3
	63	308.04	7.91	315.95	158.0	142.18	71.1	205.37	102.7	156.61	78.3
	64	319.24	7.91	327.15	163.6	147.22	73.6	212.65	106.3	160.53	80.3
	65	331.17	7.91	339.08	169.5	152.59	76.3	220.40	110.2	164.70	82.4
	66	343.30	7.91	351.21	175.6	158.05	79.0	228.29	114.1	168.95	84.5
	67	355.43	7.91	363.34	181.7	163.50	81.8	236.17	118.1	173.19	86.6
	68	367.56	7.91	375.47	187.7	168.96	84.5	244.06	122.0	177.44	88.7
	69	379.69	7.91	387.60	193.8	174.42	87.2	251.94	126.0	181.68	90.8
	70	391.82	7.91	399.73	199.9	179.88	89.9	259.83	129.9	185.93	93.0
	71	403.95	7.91	411.86	205.9	185.34	92.7	267.71	133.9	190.18	95.1
	72	416.08	7.91	423.99	212.0	190.80	95.4	275.60	137.8	194.42	97.2
	73	428.21	7.91	436.12	218.1	196.26	98.1	283.48	141.7	198.67	99.3
	74	441.08	7.91	448.99	224.5	202.05	101.0	291.84	145.9	203.17	101.6
	75	454.14	7.91	462.05	231.0	207.92	104.0	300.33	150.2	207.74	103.9
	76	467.20	7.91	475.11	237.6	213.80	106.9	308.82	154.4	212.31	106.2
	77	480.27	7.91	488.18	244.1	219.68	109.8	317.31	158.7	216.89	108.4
	78	493.33	7.91	501.24	250.6	225.56	112.8	325.80	162.9	221.46	110.7
	79	506.39	7.91	514.30	257.2	231.44	115.7	334.30	167.1	226.03	113.0
	80	519.45	7.91	527.36	263.7	237.31	118.7	342.79	171.4	230.60	115.3

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
14x73 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton pile capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
	1	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.73	0.4
	2	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	1.46	0.7
	3	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	2.19	1.1
	4	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	2.92	1.5
	5	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	3.66	1.8
	6	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	4.39	2.2
	7	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	5.12	2.6
	8	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	5.85	2.9
Clay	8.4	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	6.14	3.1
Sand	8.4	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	6.14	3.1
	9	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	7.22	3.6
Contributes to Downdrag	10	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	9.02	4.5
	11	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	10.82	5.4
	12	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	12.62	6.3
	13	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	14.42	7.2
	14	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	16.21	8.1
	15	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	18.01	9.0
	16	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	19.81	9.9
	17	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	21.61	10.8
	18	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	23.94	12.0
	19	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	26.62	13.3
	20	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	29.31	14.7
	21	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	32.00	16.0
	22	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	34.68	17.3
	23	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	37.37	18.7
	24	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	40.06	20.0
	25	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	42.74	21.4
	26	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	45.43	22.7
	27	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	48.64	24.3
	28	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	52.22	26.1
	29	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	55.79	27.9
	30	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	59.37	29.7
	31	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	62.94	31.5
	32	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	66.52	33.3
	32.3	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.0	67.59	33.8
	33	7.15	10.93	18.08	9.0	8.14	4.1	11.75	5.9	70.09	35.0
	34	17.37	10.93	28.30	14.1	12.73	6.4	18.39	9.2	73.67	36.8
	35	27.58	10.93	38.51	19.3	17.33	8.7	25.03	12.5	77.24	38.6
	36	38.69	10.93	49.62	24.8	22.33	11.2	32.25	16.1	81.13	40.6
@37.2'	37	50.42	10.93	61.35	30.7	27.61	13.8	39.88	19.9	85.24	42.6
	38	62.86	10.93	73.79	36.9	33.21	16.6	47.96	24.0	89.59	44.8
	39	75.48	10.93	86.41	43.2	38.88	19.4	56.17	28.1	94.01	47.0

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
14x73 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton pile capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
Sand	40	88.10	10.93	99.03	49.5	44.56	22.3	64.37	32.2	98.42	49.2
	41	100.72	10.93	111.65	55.8	50.24	25.1	72.57	36.3	102.84	51.4
	42	113.33	10.93	124.26	62.1	55.92	28.0	80.77	40.4	107.26	53.6
	43	125.95	10.93	136.88	68.4	61.60	30.8	88.97	44.5	111.67	55.8
	44	138.57	10.93	149.50	74.8	67.28	33.6	97.18	48.6	116.09	58.0
	45	151.19	10.93	162.12	81.1	72.95	36.5	105.38	52.7	120.50	60.3
	46	163.81	10.93	174.74	87.4	78.63	39.3	113.58	56.8	124.92	62.5
	47	177.42	10.93	188.35	94.2	84.76	42.4	122.43	61.2	129.69	64.8
	48	191.30	10.93	202.23	101.1	91.00	45.5	131.45	65.7	134.54	67.3
	49	205.18	10.93	216.11	108.1	97.25	48.6	140.47	70.2	139.40	69.7
	50	219.06	10.93	229.99	115.0	103.49	51.7	149.49	74.7	144.26	72.1
	51	232.93	10.93	243.86	121.9	109.74	54.9	158.51	79.3	149.12	74.6
	52	246.81	10.93	257.74	128.9	115.98	58.0	167.53	83.8	153.97	77.0
	53	260.69	10.93	271.62	135.8	122.23	61.1	176.55	88.3	158.83	79.4
	54	274.57	10.93	285.50	142.7	128.47	64.2	185.57	92.8	163.69	81.8
	55	288.45	10.93	299.38	149.7	134.72	67.4	194.59	97.3	168.54	84.3
	56	303.32	10.93	314.25	157.1	141.41	70.7	204.26	102.1	173.75	86.9
	57	318.46	10.93	329.39	164.7	148.22	74.1	214.10	107.1	179.05	89.5
	58	333.60	10.93	344.53	172.3	155.04	77.5	223.94	112.0	184.35	92.2
	59	348.74	10.93	359.67	179.8	161.85	80.9	233.78	116.9	189.65	94.8
	60	363.88	10.93	374.81	187.4	168.66	84.3	243.62	121.8	194.94	97.5
	61	379.01	10.93	389.94	195.0	175.47	87.7	253.46	126.7	200.24	100.1
	62	394.15	10.93	405.08	202.5	182.29	91.1	263.30	131.7	205.54	102.8
	63	409.29	10.93	420.22	210.1	189.10	94.5	273.14	136.6	210.84	105.4
	64	424.43	10.93	435.36	217.7	195.91	98.0	282.98	141.5	216.14	108.1
	65	440.56	10.93	451.49	225.7	203.17	101.6	293.47	146.7	221.79	110.9
	66	456.96	10.93	467.89	233.9	210.55	105.3	304.13	152.1	227.52	113.8
	67	473.36	10.93	484.29	242.1	217.93	109.0	314.79	157.4	233.26	116.6
	68	489.76	10.93	500.69	250.3	225.31	112.7	325.45	162.7	239.00	119.5
	69	506.16	10.93	517.09	258.5	232.69	116.3	336.11	168.1	244.74	122.4
	70	522.55	10.93	533.48	266.7	240.07	120.0	346.76	173.4	250.48	125.2
	71	538.95	10.93	549.88	274.9	247.45	123.7	357.42	178.7	256.22	128.1
	72	555.35	10.93	566.28	283.1	254.83	127.4	368.08	184.0	261.96	131.0
	73	571.75	10.93	582.68	291.3	262.20	131.1	378.74	189.4	267.70	133.8
	74	589.14	10.93	600.07	300.0	270.03	135.0	390.05	195.0	273.79	136.9
	75	606.80	10.93	617.73	308.9	277.98	139.0	401.52	200.8	279.97	140.0
	76	624.46	10.93	635.39	317.7	285.92	143.0	413.00	206.5	286.15	143.1
	77	642.12	10.93	653.05	326.5	293.87	146.9	424.48	212.2	292.33	146.2
	78	659.78	10.93	670.71	335.4	301.82	150.9	435.96	218.0	298.51	149.3
	79	677.43	10.93	688.36	344.2	309.76	154.9	447.44	223.7	304.69	152.3
	80	695.09	10.93	706.02	353.0	317.71	158.9	458.92	229.5	310.87	155.4

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
14x89 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 170 ton pile capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		**ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method**		**ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)**		**ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method**	
	(ft)	(kips)	(kips)	(kips)	(tons)	**(kips)**	**(tons)**	**(kips)**	**(tons)**	**(kips)**	**(tons)**
	1	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**0.74**	**0.4**
	2	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**1.48**	**0.7**
	3	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**2.22**	**1.1**
	4	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**2.96**	**1.5**
	5	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**3.70**	**1.8**
	6	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**4.44**	**2.2**
	7	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**5.18**	**2.6**
	8	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**5.92**	**3.0**
Clay	8.4	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**6.22**	**3.1**
Sand	8.4	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**6.22**	**3.1**
	9	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**7.40**	**3.7**
	10	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**9.38**	**4.7**
	11	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**11.36**	**5.7**
	12	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**13.35**	**6.7**
	13	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**15.33**	**7.7**
	14	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**17.31**	**8.7**
	15	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**19.30**	**9.6**
	16	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**21.28**	**10.6**
Contributes to Downdrag	17	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**23.26**	**11.6**
	18	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**25.82**	**12.9**
	19	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**28.78**	**14.4**
	20	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**31.74**	**15.9**
	21	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**34.71**	**17.4**
	22	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**37.67**	**18.8**
	23	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**40.63**	**20.3**
	24	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**43.59**	**21.8**
	25	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**46.55**	**23.3**
	26	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**49.51**	**24.8**
	27	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**53.05**	**26.5**
	28	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**56.99**	**28.5**
	29	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**60.93**	**30.5**
	30	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**64.87**	**32.4**
	31	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**68.81**	**34.4**
	32	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**72.75**	**36.4**
	33	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**76.69**	**38.3**
	33.7	0.00	0.00	0.00	0.0	**0.00**	**0.0**	**0.00**	**0.0**	**79.45**	**39.7**
	34	3.38	13.33	16.71	8.4	**7.52**	**3.8**	**10.86**	**5.4**	**80.63**	**40.3**
	35	14.63	13.33	27.96	14.0	**12.58**	**6.3**	**18.18**	**9.1**	**84.57**	**42.3**
	36	26.88	13.33	40.21	20.1	**18.09**	**9.0**	**26.14**	**13.1**	**88.86**	**44.4**
@37.2'	37	39.81	13.33	53.14	26.6	**23.91**	**12.0**	**34.54**	**17.3**	**93.38**	**46.7**
	38	53.52	13.33	66.85	33.4	**30.08**	**15.0**	**43.45**	**21.7**	**98.18**	**49.1**
	39	67.42	13.33	80.75	40.4	**36.34**	**18.2**	**52.49**	**26.2**	**103.05**	**51.5**

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
14x89 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 170 ton pile capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
Sand	40	81.33	13.33	94.66	47.3	42.60	21.3	61.53	30.8	107.91	54.0
	41	95.24	13.33	108.57	54.3	48.85	24.4	70.57	35.3	112.78	56.4
	42	109.14	13.33	122.47	61.2	55.11	27.6	79.61	39.8	117.65	58.8
	43	123.05	13.33	136.38	68.2	61.37	30.7	88.65	44.3	122.52	61.3
	44	136.96	13.33	150.29	75.1	67.63	33.8	97.69	48.8	127.38	63.7
	45	150.86	13.33	164.19	82.1	73.89	36.9	106.73	53.4	132.25	66.1
	46	164.77	13.33	178.10	89.0	80.14	40.1	115.76	57.9	137.12	68.6
	47	179.77	13.33	193.10	96.6	86.90	43.4	125.52	62.8	142.37	71.2
	48	195.07	13.33	208.40	104.2	93.78	46.9	135.46	67.7	147.72	73.9
	49	210.36	13.33	223.69	111.8	100.66	50.3	145.40	72.7	153.08	76.5
	50	225.66	13.33	238.99	119.5	107.55	53.8	155.34	77.7	158.43	79.2
	51	240.96	13.33	254.29	127.1	114.43	57.2	165.29	82.6	163.78	81.9
	52	256.25	13.33	269.58	134.8	121.31	60.7	175.23	87.6	169.14	84.6
	53	271.55	13.33	284.88	142.4	128.19	64.1	185.17	92.6	174.49	87.2
	54	286.84	13.33	300.17	150.1	135.08	67.5	195.11	97.6	179.84	89.9
	55	302.14	13.33	315.47	157.7	141.96	71.0	205.05	102.5	185.20	92.6
	56	318.53	13.33	331.86	165.9	149.34	74.7	215.71	107.9	190.93	95.5
	57	335.22	13.33	348.55	174.3	156.85	78.4	226.55	113.3	196.77	98.4
	58	351.90	13.33	365.23	182.6	164.35	82.2	237.40	118.7	202.61	101.3
	59	368.58	13.33	381.91	191.0	171.86	85.9	248.24	124.1	208.45	104.2
	60	385.27	13.33	398.60	199.3	179.37	89.7	259.09	129.5	214.29	107.1
	61	401.95	13.33	415.28	207.6	186.88	93.4	269.93	135.0	220.13	110.1
	62	418.64	13.33	431.97	216.0	194.39	97.2	280.78	140.4	225.97	113.0
	63	435.32	13.33	448.65	224.3	201.89	100.9	291.62	145.8	231.81	115.9
	64	452.01	13.33	465.34	232.7	209.40	104.7	302.47	151.2	237.65	118.8
	65	469.79	13.33	483.12	241.6	217.40	108.7	314.03	157.0	243.87	121.9
	66	487.86	13.33	501.19	250.6	225.54	112.8	325.77	162.9	250.20	125.1
	67	505.93	13.33	519.26	259.6	233.67	116.8	337.52	168.8	256.52	128.3
	68	524.00	13.33	537.33	268.7	241.80	120.9	349.27	174.6	262.85	131.4
	69	542.08	13.33	555.41	277.7	249.93	125.0	361.01	180.5	269.18	134.6
	70	560.15	13.33	573.48	286.7	258.07	129.0	372.76	186.4	275.50	137.8
	71	578.22	13.33	591.55	295.8	266.20	133.1	384.51	192.3	281.83	140.9
	72	596.29	13.33	609.62	304.8	274.33	137.2	396.25	198.1	288.15	144.1
	73	614.36	13.33	627.69	313.8	282.46	141.2	408.00	204.0	294.48	147.2
	74	633.54	13.33	646.87	323.4	291.09	145.5	420.46	210.2	301.19	150.6
	75	653.00	13.33	666.33	333.2	299.85	149.9	433.11	216.6	308.00	154.0
	76	672.46	13.33	685.79	342.9	308.61	154.3	445.76	222.9	314.81	157.4
	77	691.92	13.33	705.25	352.6	317.36	158.7	458.41	229.2	321.62	160.8
	78	711.38	13.33	724.71	362.4	326.12	163.1	471.06	235.5	328.43	164.2
	79	730.85	13.33	744.18	372.1	334.88	167.4	483.71	241.9	335.24	167.6
	80	750.31	13.33	763.64	381.8	343.64	171.8	496.37	248.2	342.06	171.0

Drilled Shaft Capacities

Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2

30-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft

Zone contributing to downdrag is based upon a 140 ton shaft capacity

Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
	1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	3	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	4	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	5	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
Contributes to Downdrag	6	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**1.13**	**0.6**
	7	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**2.27**	**1.1**
Clay	8	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**3.40**	**1.7**
Sand	9	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**7.85**	**3.9**
	10	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**12.67**	**6.3**
	11	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**17.87**	**8.9**
	12	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**23.41**	**11.7**
	13	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**29.30**	**14.6**
	14	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**35.51**	**17.8**
	15	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**42.05**	**21.0**
	16	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**48.89**	**24.4**
	17	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**56.03**	**28.0**
	18	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**63.45**	**31.7**
	18.9	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**70.38**	**35.2**
	19	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**71.15**	**35.6**
	20	17.40	99.00	116.40	58.2	9.57	49.50	**59.07**	**29.5**	**79.10**	**39.6**
	21	35.38	102.16	137.54	68.8	19.46	51.08	**70.54**	**35.3**	**87.31**	**43.7**
	22	53.90	104.00	157.90	79.0	29.65	52.00	**81.65**	**40.8**	**95.77**	**47.9**
	23	72.94	104.68	177.62	88.8	40.12	52.34	**92.46**	**46.2**	**104.46**	**52.2**
	24	92.50	104.74	197.24	98.6	50.88	52.37	**103.25**	**51.6**	**113.37**	**56.7**
	25	112.54	104.74	217.28	108.6	61.90	52.37	**114.27**	**57.1**	**122.51**	**61.3**
	26	133.04	104.74	237.78	118.9	73.17	52.37	**125.54**	**62.8**	**131.85**	**65.9**
	27	154.00	104.74	258.74	129.4	84.70	52.37	**137.07**	**68.5**	**141.39**	**70.7**
	28	175.38	104.74	280.12	140.1	96.46	52.37	**148.83**	**74.4**	**151.12**	**75.6**
	29	197.18	104.74	301.92	151.0	108.45	52.37	**160.82**	**80.4**	**161.04**	**80.5**
	30	219.36	104.74	324.10	162.1	120.65	52.37	**173.02**	**86.5**	**171.13**	**85.6**
	31	241.92	104.74	346.66	173.3	133.06	52.37	**185.43**	**92.7**	**181.38**	**90.7**
	32	264.84	104.74	369.58	184.8	145.66	52.37	**198.03**	**99.0**	**191.79**	**95.9**
	33	288.10	104.74	392.84	196.4	158.46	52.37	**210.83**	**105.4**	**202.35**	**101.2**
	34	311.68	104.74	416.42	208.2	171.42	52.37	**223.79**	**111.9**	**213.05**	**106.5**
	35	335.56	104.74	440.30	220.2	184.56	52.37	**236.93**	**118.5**	**223.89**	**111.9**
	36	359.72	104.74	464.46	232.2	197.85	52.37	**250.22**	**125.1**	**234.86**	**117.4**
@ 37.2'	37	384.16	104.74	488.90	244.5	211.29	52.37	**263.66**	**131.8**	**245.94**	**123.0**
	38	408.52	104.74	513.26	256.6	224.69	52.37	**277.06**	**138.5**	**257.00**	**128.5**
	39	432.80	104.74	537.54	268.8	238.04	52.37	**290.41**	**145.2**	**268.00**	**134.0**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
30-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton shaft capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
Sand	40	457.02	104.74	561.76	280.9	251.36	52.37	**303.73**	**151.9**	**278.98**	**139.5**
	41	481.12	104.74	585.86	292.9	264.62	52.37	**316.99**	**158.5**	**289.92**	**145.0**
	42	505.14	104.74	609.88	304.9	277.83	52.37	**330.20**	**165.1**	**300.80**	**150.4**
	43	529.06	104.74	633.80	316.9	290.98	52.37	**343.35**	**171.7**	**311.64**	**155.8**
	44	552.88	104.74	657.62	328.8	304.08	52.37	**356.45**	**178.2**	**322.43**	**161.2**
	45	576.58	104.74	681.32	340.7	317.12	52.37	**369.49**	**184.7**	**333.18**	**166.6**
	46	600.18	104.74	704.92	352.5	330.10	52.37	**382.47**	**191.2**	**343.87**	**171.9**
	47	623.64	104.74	728.38	364.2	343.00	52.37	**395.37**	**197.7**	**354.50**	**177.3**
	48	646.98	104.74	751.72	375.9	355.84	52.37	**408.21**	**204.1**	**365.08**	**182.5**
	49	670.20	104.74	774.94	387.5	368.61	52.37	**420.98**	**210.5**	**375.59**	**187.8**
	50	693.26	104.74	798.00	399.0	381.29	52.37	**433.66**	**216.8**	**386.04**	**193.0**
	51	716.20	104.74	820.94	410.5	393.91	52.37	**446.28**	**223.1**	**396.42**	**198.2**
	52	738.98	104.74	843.72	421.9	406.44	52.37	**458.81**	**229.4**	**406.75**	**203.4**
	53	761.62	104.74	866.36	433.2	418.89	52.37	**471.26**	**235.6**	**416.99**	**208.5**
	54	784.08	104.74	888.82	444.4	431.24	52.37	**483.61**	**241.8**	**427.17**	**213.6**
	55	806.40	104.74	911.14	455.6	443.52	52.37	**495.89**	**247.9**	**437.27**	**218.6**
	56	828.54	104.74	933.28	466.6	455.70	52.37	**508.07**	**254.0**	**447.29**	**223.6**
	57	850.52	104.74	955.26	477.6	467.79	52.37	**520.16**	**260.1**	**457.24**	**228.6**
	58	872.32	104.74	977.06	488.5	479.78	52.37	**532.15**	**266.1**	**467.10**	**233.6**
	59	893.92	104.74	998.66	499.3	491.66	52.37	**544.03**	**272.0**	**476.87**	**238.4**
	60	915.36	104.74	1020.10	510.1	503.45	52.37	**555.82**	**277.9**	**486.58**	**243.3**
	61	936.58	104.74	1041.32	520.7	515.12	52.37	**567.49**	**283.7**	**496.18**	**248.1**
	62	957.62	104.74	1062.36	531.2	526.69	52.37	**579.06**	**289.5**	**505.69**	**252.8**
	63	978.46	104.74	1083.20	541.6	538.15	52.37	**590.52**	**295.3**	**515.12**	**257.6**
	64	999.08	104.74	1103.82	551.9	549.49	52.37	**601.86**	**300.9**	**524.45**	**262.2**
	65	1019.48	104.74	1124.22	562.1	560.71	52.37	**613.08**	**306.5**	**533.67**	**266.8**
	66	1039.68	104.74	1144.42	572.2	571.82	52.37	**624.19**	**312.1**	**542.81**	**271.4**
	67	1059.66	104.74	1164.40	582.2	582.81	52.37	**635.18**	**317.6**	**551.84**	**275.9**
	68	1079.40	104.74	1184.14	592.1	593.67	52.37	**646.04**	**323.0**	**560.76**	**280.4**
	69	1098.90	104.74	1203.64	601.8	604.40	52.37	**656.77**	**328.4**	**569.58**	**284.8**
	70	1118.18	104.74	1222.92	611.5	615.00	52.37	**667.37**	**333.7**	**578.30**	**289.1**
	71	1137.22	104.74	1241.96	621.0	625.47	52.37	**677.84**	**338.9**	**586.90**	**293.4**
	72	1156.00	104.74	1260.74	630.4	635.80	52.37	**688.17**	**344.1**	**595.40**	**297.7**
	73	1174.54	104.74	1279.28	639.6	646.00	52.37	**698.37**	**349.2**	**603.77**	**301.9**
	74	1192.82	104.74	1297.56	648.8	656.05	52.37	**708.42**	**354.2**	**612.03**	**306.0**
	75	1210.84	104.74	1315.58	657.8	665.96	52.37	**718.33**	**359.2**	**620.17**	**310.1**
	76	1228.58	104.74	1333.32	666.7	675.72	52.37	**728.09**	**364.0**	**628.19**	**314.1**
	77	1246.06	104.74	1350.80	675.4	685.33	52.37	**737.70**	**368.9**	**636.08**	**318.0**
	78	1263.28	104.74	1368.02	684.0	694.80	52.37	**747.17**	**373.6**	**643.86**	**321.9**
	79	1280.20	104.74	1384.94	692.5	704.11	52.37	**756.48**	**378.2**	**651.50**	**325.8**
	80	1296.84	104.74	1401.58	700.8	713.26	52.37	**765.63**	**382.8**	**659.02**	**329.5**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
36-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton shaft capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	R_n Total Nominal Geotechnical Axial Resistance (tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**ϕR_n Total Factored Geotechnical Axial Resistance (tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (tons)**
	1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	3	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	4	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	5	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	6	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**1.36**	**0.7**
	7	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**2.72**	**1.4**
Clay	8	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**4.08**	**2.0**
Sand	9	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**9.42**	**4.7**
	10	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**15.21**	**7.6**
	11	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**21.43**	**10.7**
	12	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**28.09**	**14.0**
Contributes to Downdrag	13	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**35.16**	**17.6**
	14	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**42.62**	**21.3**
	15	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**50.46**	**25.2**
	16	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**58.67**	**29.3**
	17	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**67.23**	**33.6**
	17.1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**68.13**	**34.1**
	18	39.16	112.64	151.80	75.9	21.54	56.32	**77.86**	**38.9**	**76.14**	**38.1**
	19	79.80	117.66	197.46	98.7	43.89	58.83	**102.72**	**51.4**	**85.37**	**42.7**
	20	121.84	122.70	244.54	122.3	67.01	61.35	**128.36**	**64.2**	**94.92**	**47.5**
	21	82.62	127.72	210.34	105.2	45.44	63.86	**109.30**	**54.7**	**104.77**	**52.4**
	22	104.98	132.74	237.72	118.9	57.74	66.37	**124.11**	**62.1**	**114.93**	**57.5**
	23	127.96	137.78	265.74	132.9	70.38	68.89	**139.27**	**69.6**	**125.36**	**62.7**
	24	151.54	142.70	294.24	147.1	83.35	71.35	**154.70**	**77.3**	**136.05**	**68.0**
	25	175.70	146.54	322.24	161.1	96.64	73.27	**169.91**	**85.0**	**147.01**	**73.5**
	26	200.42	149.14	349.56	174.8	110.23	74.57	**184.80**	**92.4**	**158.22**	**79.1**
	27	225.68	150.42	376.10	188.1	124.12	75.21	**199.33**	**99.7**	**169.67**	**84.8**
	28	251.44	150.84	402.28	201.1	138.29	75.42	**213.71**	**106.9**	**181.35**	**90.7**
	29	277.68	150.84	428.52	214.3	152.72	75.42	**228.14**	**114.1**	**193.24**	**96.6**
	30	304.40	150.84	455.24	227.6	167.42	75.42	**242.84**	**121.4**	**205.35**	**102.7**
	31	331.56	150.84	482.40	241.2	182.36	75.42	**257.78**	**128.9**	**217.65**	**108.8**
	32	359.14	150.84	509.98	255.0	197.53	75.42	**272.95**	**136.5**	**230.14**	**115.1**
	33	387.12	150.84	537.96	269.0	212.92	75.42	**288.34**	**144.2**	**242.82**	**121.4**
	34	415.48	150.84	566.32	283.2	228.51	75.42	**303.93**	**152.0**	**255.66**	**127.8**
	35	444.22	150.84	595.06	297.5	244.32	75.42	**319.74**	**159.9**	**268.66**	**134.3**
	36	473.28	150.84	624.12	312.1	260.30	75.42	**335.72**	**167.9**	**281.83**	**140.9**
@ 37.2'	37	502.66	150.84	653.50	326.8	276.46	75.42	**351.88**	**175.9**	**295.13**	**147.6**
	38	531.96	150.84	682.80	341.4	292.58	75.42	**368.00**	**184.0**	**308.39**	**154.2**
	39	561.16	150.84	712.00	356.0	308.64	75.42	**384.06**	**192.0**	**321.61**	**160.8**

Drilled Shaft Capacities

Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2

36-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton shaft capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
Sand	40	590.26	150.84	741.10	370.6	324.64	75.42	**400.06**	**200.0**	**334.78**	**167.4**
	41	619.26	150.84	770.10	385.1	340.59	75.42	**416.01**	**208.0**	**347.90**	**173.9**
	42	648.12	150.84	798.96	399.5	356.47	75.42	**431.89**	**215.9**	**360.96**	**180.5**
	43	676.88	150.84	827.72	413.9	372.28	75.42	**447.70**	**223.9**	**373.97**	**187.0**
	44	705.50	150.84	856.34	428.2	388.03	75.42	**463.45**	**231.7**	**386.92**	**193.5**
	45	733.98	150.84	884.82	442.4	403.69	75.42	**479.11**	**239.6**	**399.82**	**199.9**
	46	762.34	150.84	913.18	456.6	419.29	75.42	**494.71**	**247.4**	**412.65**	**206.3**
	47	790.54	150.84	941.38	470.7	434.80	75.42	**510.22**	**255.1**	**425.40**	**212.7**
	48	818.58	150.84	969.42	484.7	450.22	75.42	**525.64**	**262.8**	**438.09**	**219.0**
	49	846.46	150.84	997.30	498.7	465.55	75.42	**540.97**	**270.5**	**450.71**	**225.4**
	50	874.18	150.84	1025.02	512.5	480.80	75.42	**556.22**	**278.1**	**463.24**	**231.6**
	51	901.74	150.84	1052.58	526.3	495.96	75.42	**571.38**	**285.7**	**475.71**	**237.9**
	52	929.10	150.84	1079.94	540.0	511.01	75.42	**586.43**	**293.2**	**488.09**	**244.0**
	53	956.28	150.84	1107.12	553.6	525.95	75.42	**601.37**	**300.7**	**500.39**	**250.2**
	54	983.28	150.84	1134.12	567.1	540.80	75.42	**616.22**	**308.1**	**512.60**	**256.3**
	55	1010.06	150.84	1160.90	580.5	555.53	75.42	**630.95**	**315.5**	**524.72**	**262.4**
	56	1036.66	150.84	1187.50	593.8	570.16	75.42	**645.58**	**322.8**	**536.75**	**268.4**
	57	1063.04	150.84	1213.88	606.9	584.67	75.42	**660.09**	**330.0**	**548.68**	**274.3**
	58	1089.20	150.84	1240.04	620.0	599.06	75.42	**674.48**	**337.2**	**560.52**	**280.3**
	59	1115.16	150.84	1266.00	633.0	613.34	75.42	**688.76**	**344.4**	**572.25**	**286.1**
	60	1140.86	150.84	1291.70	645.9	627.47	75.42	**702.89**	**351.4**	**583.89**	**291.9**
	61	1166.36	150.84	1317.20	658.6	641.50	75.42	**716.92**	**358.5**	**595.42**	**297.7**
	62	1191.60	150.84	1342.44	671.2	655.38	75.42	**730.80**	**365.4**	**606.83**	**303.4**
	63	1216.60	150.84	1367.44	683.7	669.13	75.42	**744.55**	**372.3**	**618.14**	**309.1**
	64	1241.34	150.84	1392.18	696.1	682.74	75.42	**758.16**	**379.1**	**629.34**	**314.7**
	65	1265.84	150.84	1416.68	708.3	696.21	75.42	**771.63**	**385.8**	**640.41**	**320.2**
	66	1290.06	150.84	1440.90	720.5	709.53	75.42	**784.95**	**392.5**	**651.37**	**325.7**
	67	1314.02	150.84	1464.86	732.4	722.71	75.42	**798.13**	**399.1**	**662.21**	**331.1**
	68	1337.70	150.84	1488.54	744.3	735.74	75.42	**811.16**	**405.6**	**672.92**	**336.5**
	69	1361.10	150.84	1511.94	756.0	748.61	75.42	**824.03**	**412.0**	**683.50**	**341.8**
	70	1384.22	150.84	1535.06	767.5	761.32	75.42	**836.74**	**418.4**	**693.96**	**347.0**
	71	1407.04	150.84	1557.88	778.9	773.87	75.42	**849.29**	**424.6**	**704.28**	**352.1**
	72	1429.56	150.84	1580.40	790.2	786.26	75.42	**861.68**	**430.8**	**714.47**	**357.2**
	73	1451.78	150.84	1602.62	801.3	798.48	75.42	**873.90**	**436.9**	**724.52**	**362.3**
	74	1473.70	150.84	1624.54	812.3	810.54	75.42	**885.96**	**443.0**	**734.43**	**367.2**
	75	1495.30	150.84	1646.14	823.1	822.42	75.42	**897.84**	**448.9**	**744.21**	**372.1**
	76	1516.58	150.84	1667.42	833.7	834.12	75.42	**909.54**	**454.8**	**753.83**	**376.9**
	77	1537.52	150.84	1688.36	844.2	845.64	75.42	**921.06**	**460.5**	**763.30**	**381.7**
	78	1558.14	150.84	1708.98	854.5	856.98	75.42	**932.40**	**466.2**	**772.63**	**386.3**
	79	1578.42	150.84	1729.26	864.6	868.13	75.42	**943.55**	**471.8**	**781.81**	**390.9**
	80	1598.36	150.84	1749.20	874.6	879.10	75.42	**954.52**	**477.3**	**790.83**	**395.4**

Drilled Shaft Capacities

Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2

42-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton shaft capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	R_n Total Nominal Geotechnical Axial Resistance (tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**ϕR_n Total Factored Geotechnical Axial Resistance (tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (tons)**
	1	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	0.00	0.0
	2	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	0.00	0.0
	3	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	0.00	0.0
Contributes to Downdrag	4	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	0.00	0.0
	5	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	0.00	0.0
	6	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	1.59	0.8
	7	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	3.18	1.6
Clay	8	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	4.76	2.4
Sand	9	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	10.99	5.5
	10	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	17.74	8.9
	11	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	25.01	12.5
	12	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	32.78	16.4
	13	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	41.02	20.5
	14	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	49.72	24.9
	15	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	58.87	29.4
	15.3	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.0	61.74	30.9
	16	21.22	124.28	145.50	72.8	11.67	62.14	73.81	36.9	68.44	34.2
	17	43.36	130.16	173.52	86.8	23.85	65.08	88.93	44.5	78.44	39.2
	18	66.38	136.02	202.40	101.2	36.51	68.01	104.52	52.3	88.83	44.4
	19	90.26	141.88	232.14	116.1	49.64	70.94	120.58	60.3	99.60	49.8
	20	114.94	147.76	262.70	131.4	63.22	73.88	137.10	68.5	110.74	55.4
	21	140.42	153.62	294.04	147.0	77.23	76.81	154.04	77.0	122.24	61.1
	22	166.64	159.48	326.12	163.1	91.65	79.74	171.39	85.7	134.08	67.0
	23	193.60	165.36	358.96	179.5	106.48	82.68	189.16	94.6	146.24	73.1
	24	221.24	171.22	392.46	196.2	121.68	85.61	207.29	103.6	158.73	79.4
	25	249.56	177.08	426.64	213.3	137.26	88.54	225.80	112.9	171.51	85.8
	26	278.54	182.94	461.48	230.7	153.20	91.47	244.67	122.3	184.59	92.3
	27	308.12	188.82	496.94	248.5	169.47	94.41	263.88	131.9	197.95	99.0
	28	338.28	194.36	532.64	266.3	186.05	97.18	283.23	141.6	211.57	105.8
	29	369.02	198.84	567.86	283.9	202.96	99.42	302.38	151.2	225.45	112.7
	30	400.30	202.10	602.40	301.2	220.17	101.05	321.22	160.6	239.57	119.8
	31	432.08	204.10	636.18	318.1	237.64	102.05	339.69	169.8	253.93	127.0
	32	464.36	205.02	669.38	334.7	255.40	102.51	357.91	179.0	268.51	134.3
	33	497.10	205.30	702.40	351.2	273.41	102.65	376.06	188.0	283.28	141.6
	34	530.28	205.30	735.58	367.8	291.65	102.65	394.30	197.2	298.27	149.1
	35	563.86	205.30	769.16	384.6	310.12	102.65	412.77	206.4	313.44	156.7
	36	597.86	205.30	803.16	401.6	328.82	102.65	431.47	215.7	328.80	164.4
@ 37.2'	37	631.74	205.30	837.04	418.5	347.46	102.65	450.11	225.1	344.32	172.2
	38	665.54	205.30	870.84	435.4	366.05	102.65	468.70	234.3	359.79	179.9
	39	699.22	205.30	904.52	452.3	384.57	102.65	487.22	243.6	375.21	187.6

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
42-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton shaft capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	R_n Total Nominal Geotechnical Axial Resistance (tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**ϕR_n Total Factored Geotechnical Axial Resistance (tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (tons)**
Sand	40	732.80	205.30	938.10	469.1	403.04	102.65	**505.69**	**252.8**	**390.57**	**195.3**
	41	766.24	205.30	971.54	485.8	421.43	102.65	**524.08**	**262.0**	**405.88**	**202.9**
	42	799.56	205.30	1004.86	502.4	439.76	102.65	**542.41**	**271.2**	**421.13**	**210.6**
	43	832.74	205.30	1038.04	519.0	458.01	102.65	**560.66**	**280.3**	**436.30**	**218.2**
	44	865.78	205.30	1071.08	535.5	476.18	102.65	**578.83**	**289.4**	**451.41**	**225.7**
	45	898.66	205.30	1103.96	552.0	494.26	102.65	**596.91**	**298.5**	**466.45**	**233.2**
	46	931.36	205.30	1136.66	568.3	512.25	102.65	**614.90**	**307.4**	**481.42**	**240.7**
	47	963.92	205.30	1169.22	584.6	530.16	102.65	**632.81**	**316.4**	**496.30**	**248.2**
	48	996.30	205.30	1201.60	600.8	547.97	102.65	**650.62**	**325.3**	**511.11**	**255.6**
	49	1028.48	205.30	1233.78	616.9	565.66	102.65	**668.31**	**334.2**	**525.82**	**262.9**
	50	1060.48	205.30	1265.78	632.9	583.26	102.65	**685.91**	**343.0**	**540.46**	**270.2**
	51	1092.28	205.30	1297.58	648.8	600.75	102.65	**703.40**	**351.7**	**554.99**	**277.5**
	52	1123.88	205.30	1329.18	664.6	618.13	102.65	**720.78**	**360.4**	**569.44**	**284.7**
	53	1155.28	205.30	1360.58	680.3	635.40	102.65	**738.05**	**369.0**	**583.78**	**291.9**
	54	1186.44	205.30	1391.74	695.9	652.54	102.65	**755.19**	**377.6**	**598.03**	**299.0**
	55	1217.38	205.30	1422.68	711.3	669.56	102.65	**772.21**	**386.1**	**612.17**	**306.1**
	56	1248.10	205.30	1453.40	726.7	686.46	102.65	**789.11**	**394.6**	**626.21**	**313.1**
	57	1278.56	205.30	1483.86	741.9	703.21	102.65	**805.86**	**402.9**	**640.13**	**320.1**
	58	1308.78	205.30	1514.08	757.0	719.83	102.65	**822.48**	**411.2**	**653.94**	**327.0**
	59	1338.74	205.30	1544.04	772.0	736.31	102.65	**838.96**	**419.5**	**667.63**	**333.8**
	60	1368.44	205.30	1573.74	786.9	752.64	102.65	**855.29**	**427.6**	**681.20**	**340.6**
	61	1397.88	205.30	1603.18	801.6	768.83	102.65	**871.48**	**435.7**	**694.65**	**347.3**
	62	1427.04	205.30	1632.34	816.2	784.87	102.65	**887.52**	**443.8**	**707.98**	**354.0**
	63	1455.90	205.30	1661.20	830.6	800.75	102.65	**903.40**	**451.7**	**721.16**	**360.6**
	64	1484.48	205.30	1689.78	844.9	816.46	102.65	**919.11**	**459.6**	**734.22**	**367.1**
	65	1512.78	205.30	1718.08	859.0	832.03	102.65	**934.68**	**467.3**	**747.14**	**373.6**
	66	1540.76	205.30	1746.06	873.0	847.42	102.65	**950.07**	**475.0**	**759.93**	**380.0**
	67	1568.42	205.30	1773.72	886.9	862.63	102.65	**965.28**	**482.6**	**772.58**	**386.3**
	68	1595.78	205.30	1801.08	900.5	877.68	102.65	**980.33**	**490.2**	**785.07**	**392.5**
	69	1622.82	205.30	1828.12	914.1	892.55	102.65	**995.20**	**497.6**	**797.42**	**398.7**
	70	1649.50	205.30	1854.80	927.4	907.23	102.65	**1009.88**	**504.9**	**809.62**	**404.8**
	71	1675.86	205.30	1881.16	940.6	921.72	102.65	**1024.37**	**512.2**	**821.66**	**410.8**
	72	1701.88	205.30	1907.18	953.6	936.03	102.65	**1038.68**	**519.3**	**833.55**	**416.8**
	73	1727.54	205.30	1932.84	966.4	950.15	102.65	**1052.80**	**526.4**	**845.28**	**422.6**
	74	1752.86	205.30	1958.16	979.1	964.07	102.65	**1066.72**	**533.4**	**856.84**	**428.4**
	75	1777.80	205.30	1983.10	991.6	977.79	102.65	**1080.44**	**540.2**	**868.24**	**434.1**
	76	1802.36	205.30	2007.66	1003.8	991.30	102.65	**1093.95**	**547.0**	**879.46**	**439.7**
	77	1826.56	205.30	2031.86	1015.9	1004.61	102.65	**1107.26**	**553.6**	**890.52**	**445.3**
	78	1850.36	205.30	2055.66	1027.8	1017.70	102.65	**1120.35**	**560.2**	**901.40**	**450.7**
	79	1873.78	205.30	2079.08	1039.5	1030.58	102.65	**1133.23**	**566.6**	**912.10**	**456.1**
	80	1896.80	205.30	2102.10	1051.1	1043.24	102.65	**1145.89**	**572.9**	**922.63**	**461.3**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
48-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton shaft capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
Contributes to Downdrag	1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	3	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	4	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	5	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	6	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	7	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
Clay	8	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
Sand	9	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**12.56**	**6.3**
	10	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**20.27**	**10.1**
	11	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**28.58**	**14.3**
	12	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**37.45**	**18.7**
	13	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**46.87**	**23.4**
	13.2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**48.86**	**24.4**
	14	21.94	131.84	153.78	76.9	12.07	65.92	**77.99**	**39.0**	**56.83**	**28.4**
	15	45.00	138.54	183.54	91.8	24.75	69.27	**94.02**	**47.0**	**67.28**	**33.6**
	16	69.16	145.24	214.40	107.2	38.04	72.62	**110.66**	**55.3**	**78.23**	**39.1**
	17	94.36	151.96	246.32	123.2	51.90	75.98	**127.88**	**63.9**	**89.64**	**44.8**
	18	120.56	158.66	279.22	139.6	66.31	79.33	**145.64**	**72.8**	**101.51**	**50.8**
	19	147.74	165.36	313.10	156.6	81.26	82.68	**163.94**	**82.0**	**113.82**	**56.9**
	20	175.86	172.06	347.92	174.0	96.72	86.03	**182.75**	**91.4**	**126.56**	**63.3**
	21	204.88	178.76	383.64	191.8	112.68	89.38	**202.06**	**101.0**	**139.70**	**69.8**
	22	234.78	185.48	420.26	210.1	129.13	92.74	**221.87**	**110.9**	**153.23**	**76.6**
	23	265.50	192.18	457.68	228.8	146.03	96.09	**242.12**	**121.1**	**167.13**	**83.6**
	24	297.02	198.88	495.90	248.0	163.36	99.44	**262.80**	**131.4**	**181.41**	**90.7**
	25	329.32	205.58	534.90	267.5	181.13	102.79	**283.92**	**142.0**	**196.01**	**98.0**
	26	362.36	212.28	574.64	287.3	199.30	106.14	**305.44**	**152.7**	**210.96**	**105.5**
	27	396.08	218.98	615.06	307.5	217.84	109.49	**327.33**	**163.7**	**226.23**	**113.1**
	28	430.50	225.70	656.20	328.1	236.78	112.85	**349.63**	**174.8**	**241.80**	**120.9**
	29	465.56	232.40	697.96	349.0	256.06	116.20	**372.26**	**186.1**	**257.65**	**128.8**
	30	501.24	239.10	740.34	370.2	275.68	119.55	**395.23**	**197.6**	**273.80**	**136.9**
	31	537.52	245.80	783.32	391.7	295.64	122.90	**418.54**	**209.3**	**290.20**	**145.1**
	32	574.34	252.30	826.64	413.3	315.89	126.15	**442.04**	**221.0**	**306.86**	**153.4**
	33	611.72	257.78	869.50	434.8	336.45	128.89	**465.34**	**232.7**	**323.76**	**161.9**
	34	649.58	262.12	911.70	455.9	357.27	131.06	**488.33**	**244.2**	**340.88**	**170.4**
	35	687.92	265.20	953.12	476.6	378.36	132.60	**510.96**	**255.5**	**358.22**	**179.1**
	36	726.72	267.02	993.74	496.9	399.70	133.51	**533.21**	**266.6**	**375.77**	**187.9**
@ 37.2'	37	765.96	267.88	1033.84	516.9	421.28	133.94	**555.22**	**277.6**	**393.50**	**196.7**
	38	805.06	268.16	1073.22	536.6	442.78	134.08	**576.86**	**288.4**	**411.18**	**205.6**
	39	844.02	268.16	1112.18	556.1	464.21	134.08	**598.29**	**299.1**	**428.81**	**214.4**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2
48-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Zone contributing to downdrag is based upon a 140 ton shaft capacity
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	R_n Total Nominal Geotechnical Axial Resistance (tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**ϕR_n Total Factored Geotechnical Axial Resistance (tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (tons)**
Sand	40	882.86	268.16	1151.02	575.5	485.57	134.08	**619.65**	**309.8**	**446.37**	**223.2**
	41	921.54	268.16	1189.70	594.9	506.85	134.08	**640.93**	**320.5**	**463.86**	**231.9**
	42	960.08	268.16	1228.24	614.1	528.04	134.08	**662.12**	**331.1**	**481.29**	**240.6**
	43	998.44	268.16	1266.60	633.3	549.14	134.08	**683.22**	**341.6**	**498.63**	**249.3**
	44	1036.64	268.16	1304.80	652.4	570.15	134.08	**704.23**	**352.1**	**515.90**	**257.9**
	45	1074.66	268.16	1342.82	671.4	591.06	134.08	**725.14**	**362.6**	**533.09**	**266.5**
	46	1112.48	268.16	1380.64	690.3	611.86	134.08	**745.94**	**373.0**	**550.19**	**275.1**
	47	1150.10	268.16	1418.26	709.1	632.56	134.08	**766.64**	**383.3**	**567.20**	**283.6**
	48	1187.52	268.16	1455.68	727.8	653.14	134.08	**787.22**	**393.6**	**584.12**	**292.1**
	49	1224.72	268.16	1492.88	746.4	673.60	134.08	**807.68**	**403.8**	**600.94**	**300.5**
	50	1261.70	268.16	1529.86	764.9	693.94	134.08	**828.02**	**414.0**	**617.66**	**308.8**
	51	1298.44	268.16	1566.60	783.3	714.14	134.08	**848.22**	**424.1**	**634.28**	**317.1**
	52	1334.94	268.16	1603.10	801.6	734.22	134.08	**868.30**	**434.1**	**650.78**	**325.4**
	53	1371.20	268.16	1639.36	819.7	754.16	134.08	**888.24**	**444.1**	**667.18**	**333.6**
	54	1407.20	268.16	1675.36	837.7	773.96	134.08	**908.04**	**454.0**	**683.46**	**341.7**
	55	1442.94	268.16	1711.10	855.6	793.62	134.08	**927.70**	**463.8**	**699.63**	**349.8**
	56	1478.42	268.16	1746.58	873.3	813.13	134.08	**947.21**	**473.6**	**715.66**	**357.8**
	57	1513.60	268.16	1781.76	890.9	832.48	134.08	**966.56**	**483.3**	**731.58**	**365.8**
	58	1548.50	268.16	1816.66	908.3	851.68	134.08	**985.76**	**492.9**	**747.36**	**373.7**
	59	1583.10	268.16	1851.26	925.6	870.71	134.08	**1004.79**	**502.4**	**763.00**	**381.5**
	60	1617.38	268.16	1885.54	942.8	889.56	134.08	**1023.64**	**511.8**	**778.52**	**389.3**
	61	1651.36	268.16	1919.52	959.8	908.25	134.08	**1042.33**	**521.2**	**793.88**	**396.9**
	62	1685.04	268.16	1953.20	976.6	926.77	134.08	**1060.85**	**530.4**	**809.11**	**404.6**
	63	1718.36	268.16	1986.52	993.3	945.10	134.08	**1079.18**	**539.6**	**824.19**	**412.1**
	64	1751.36	268.16	2019.52	1009.8	963.25	134.08	**1097.33**	**548.7**	**839.11**	**419.6**
	65	1784.00	268.16	2052.16	1026.1	981.20	134.08	**1115.28**	**557.6**	**853.88**	**426.9**
	66	1816.30	268.16	2084.46	1042.2	998.97	134.08	**1133.05**	**566.5**	**868.49**	**434.2**
	67	1848.24	268.16	2116.40	1058.2	1016.53	134.08	**1150.61**	**575.3**	**882.94**	**441.5**
	68	1879.82	268.16	2147.98	1074.0	1033.90	134.08	**1167.98**	**584.0**	**897.22**	**448.6**
	69	1911.00	268.16	2179.16	1089.6	1051.05	134.08	**1185.13**	**592.6**	**911.33**	**455.7**
	70	1941.82	268.16	2209.98	1105.0	1068.00	134.08	**1202.08**	**601.0**	**925.27**	**462.6**
	71	1972.24	268.16	2240.40	1120.2	1084.73	134.08	**1218.81**	**609.4**	**939.04**	**469.5**
	72	2002.26	268.16	2270.42	1135.2	1101.24	134.08	**1235.32**	**617.7**	**952.62**	**476.3**
	73	2031.88	268.16	2300.04	1150.0	1117.53	134.08	**1251.61**	**625.8**	**966.03**	**483.0**
	74	2061.08	268.16	2329.24	1164.6	1133.59	134.08	**1267.67**	**633.8**	**979.25**	**489.6**
	75	2089.86	268.16	2358.02	1179.0	1149.42	134.08	**1283.50**	**641.8**	**992.27**	**496.1**
	76	2118.20	268.16	2386.36	1193.2	1165.01	134.08	**1299.09**	**649.5**	**1005.10**	**502.6**
	77	2146.12	268.16	2414.28	1207.1	1180.37	134.08	**1314.45**	**657.2**	**1017.74**	**508.9**
	78	2173.58	268.16	2441.74	1220.9	1195.47	134.08	**1329.55**	**664.8**	**1030.17**	**515.1**
	79	2200.60	268.16	2468.76	1234.4	1210.33	134.08	**1344.41**	**672.2**	**1042.40**	**521.2**
	80	2227.16	268.16	2495.32	1247.7	1224.94	134.08	**1359.02**	**679.5**	**1054.43**	**527.2**

Appendix H

Single Shaft / Pile Capacity Estimates for Piers 1 to 5

Resistance Factors for LRFD*

Driven Piles

	Analysis Methodology	Φ
Axial Capacity		
Skin Friction and End Bearing in Clays	α-Method	0.35
Skin Friction and End Bearing in Sands	Nordlund/Thurman Method	0.45
Uplift Resistance		
Clays	α-Method	0.25
Sands	Nordlund Method	0.35
Axial Capacity - Dynamic Analysis		
Driving Criteria established by dynamic test with signal matching at the beginning of redrive conditions only of at least one production pile per pier, but no less than the number of tests per site provided in Table 10.5.5.2.3-3. Quality control of remaining piles by calibrated wave equation and/or dynamic testing		0.65

Drilled Shafts

Resistance Mechanism	Analysis Methodology	Φ
Axial Capacity		
Side Resistance in Clays	α-Method	0.45
End Bearing in Clays	Total Stress	0.40
Side Resistance in Sands	β-Method	0.55
End Bearing in Sands	SPT Method	0.50
Uplift Resistance		
Clays	α-method	0.35
Sands	β-Method	0.45

* Resistance Factors from AASHTO LRFD Bridge Design Specifications, 3rd Edition (Including 2005 and 2006 Interim Updates), Pages 10-41 for Driven Piles and 10-45 for Drilled Shafts

Steel H-Pile Capacities

Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5

12x53 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
	1	2.47	0.73	3.20	1.6	1.12	0.6	2.08	1.0	0.62	0.3
	2	4.94	0.73	5.67	2.8	1.99	1.0	3.69	1.8	1.24	0.6
	3	7.42	0.73	8.15	4.1	2.85	1.4	5.29	2.6	1.85	0.9
	4	9.89	0.73	10.62	5.3	3.72	1.9	6.90	3.5	2.47	1.2
	5	12.36	0.73	13.09	6.5	4.58	2.3	8.51	4.3	3.09	1.5
	6	14.83	0.73	15.56	7.8	5.45	2.7	10.12	5.1	3.71	1.9
	7	17.30	0.73	18.03	9.0	6.31	3.2	11.72	5.9	4.33	2.2
	8	19.78	0.73	20.51	10.3	7.18	3.6	13.33	6.7	4.94	2.5
Clay	8.4	20.77	0.73	21.50	10.7	7.52	3.8	13.97	7.0	5.19	2.6
Sand	8.4	20.77	6.76	27.53	13.8	10.31	5.2	17.89	8.9	5.19	2.6
	9	23.03	7.91	30.94	15.5	11.85	5.9	20.11	10.1	5.99	3.0
	10	26.84	7.91	34.75	17.4	13.56	6.8	22.59	11.3	7.32	3.7
	11	30.64	7.91	38.55	19.3	15.27	7.6	25.06	12.5	8.65	4.3
	12	34.44	7.91	42.35	21.2	16.98	8.5	27.53	13.8	9.98	5.0
	13	38.25	7.91	46.16	23.1	18.69	9.3	30.00	15.0	11.31	5.7
	14	42.05	7.91	49.96	25.0	20.41	10.2	32.47	16.2	12.64	6.3
	15	45.85	7.91	53.76	26.9	22.12	11.1	34.95	17.5	13.97	7.0
	16	49.66	7.91	57.57	28.8	23.83	11.9	37.42	18.7	15.30	7.7
	17	53.46	7.91	61.37	30.7	25.54	12.8	39.89	19.9	16.63	8.3
	18	58.37	7.91	66.28	33.1	27.75	13.9	43.08	21.5	18.35	9.2
	19	64.05	7.91	71.96	36.0	30.31	15.2	46.77	23.4	20.34	10.2
	20	69.73	7.91	77.64	38.8	32.86	16.4	50.46	25.2	22.33	11.2
	21	75.41	7.91	83.32	41.7	35.42	17.7	54.16	27.1	24.32	12.2
	22	81.09	7.91	89.00	44.5	37.97	19.0	57.85	28.9	26.30	13.2
	23	86.76	7.91	94.67	47.3	40.53	20.3	61.54	30.8	28.29	14.1
	24	92.44	7.91	100.35	50.2	43.08	21.5	65.23	32.6	30.28	15.1
	25	98.12	7.91	106.03	53.0	45.64	22.8	68.92	34.5	32.27	16.1
	26	103.80	7.91	111.71	55.9	48.19	24.1	72.61	36.3	34.25	17.1
	27	110.59	7.91	118.50	59.2	51.25	25.6	77.02	38.5	36.63	18.3
	28	118.14	7.91	126.05	63.0	54.65	27.3	81.93	41.0	39.27	19.6
	29	125.70	7.91	133.61	66.8	58.05	29.0	86.84	43.4	41.92	21.0
	30	133.25	7.91	141.16	70.6	61.45	30.7	91.75	45.9	44.56	22.3
	31	140.80	7.91	148.71	74.4	64.85	32.4	96.66	48.3	47.21	23.6
	32	148.36	7.91	156.27	78.1	68.24	34.1	101.58	50.8	49.85	24.9
	33	155.91	7.91	163.82	81.9	71.64	35.8	106.49	53.2	52.49	26.2
	34	163.47	7.91	171.38	85.7	75.04	37.5	111.40	55.7	55.14	27.6
	35	171.02	7.91	178.93	89.5	78.44	39.2	116.31	58.2	57.78	28.9
	36	179.24	7.91	187.15	93.6	82.14	41.1	121.65	60.8	60.66	30.3
@ 37.2'	37	187.92	7.91	195.83	97.9	86.05	43.0	127.29	63.6	63.70	31.8
	38	197.12	7.91	205.03	102.5	90.19	45.1	133.27	66.6	66.92	33.5
	39	206.46	7.91	214.37	107.2	94.39	47.2	139.34	69.7	70.18	35.1

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
12x53 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
Sand	40	215.79	7.91	223.70	111.9	98.59	49.3	145.41	72.7	73.45	36.7
	41	225.12	7.91	233.03	116.5	102.79	51.4	151.47	75.7	76.72	38.4
	42	234.46	7.91	242.37	121.2	106.99	53.5	157.54	78.8	79.98	40.0
	43	243.79	7.91	251.70	125.9	111.19	55.6	163.61	81.8	83.25	41.6
	44	253.12	7.91	261.03	130.5	115.39	57.7	169.67	84.8	86.52	43.3
	45	262.46	7.91	270.37	135.2	119.59	59.8	175.74	87.9	89.78	44.9
	46	271.79	7.91	279.70	139.9	123.79	61.9	181.81	90.9	93.05	46.5
	47	281.86	7.91	289.77	144.9	128.32	64.2	188.35	94.2	96.57	48.3
	48	292.13	7.91	300.04	150.0	132.94	66.5	195.02	97.5	100.17	50.1
	49	302.39	7.91	310.30	155.2	137.56	68.8	201.70	100.8	103.76	51.9
	50	312.66	7.91	320.57	160.3	142.18	71.1	208.37	104.2	107.35	53.7
	51	322.93	7.91	330.84	165.4	146.80	73.4	215.04	107.5	110.95	55.5
	52	333.19	7.91	341.10	170.6	151.42	75.7	221.72	110.9	114.54	57.3
	53	343.46	7.91	351.37	175.7	156.04	78.0	228.39	114.2	118.13	59.1
	54	353.73	7.91	361.64	180.8	160.66	80.3	235.06	117.5	121.73	60.9
	55	363.99	7.91	371.90	186.0	165.28	82.6	241.74	120.9	125.32	62.7
	56	375.00	7.91	382.91	191.5	170.23	85.1	248.89	124.4	129.17	64.6
	57	386.19	7.91	394.10	197.1	175.27	87.6	256.17	128.1	133.09	66.5
	58	397.39	7.91	405.30	202.7	180.31	90.2	263.45	131.7	137.01	68.5
	59	408.59	7.91	416.50	208.2	185.35	92.7	270.72	135.4	140.93	70.5
	60	419.79	7.91	427.70	213.8	190.39	95.2	278.00	139.0	144.85	72.4
	61	430.99	7.91	438.90	219.4	195.43	97.7	285.28	142.6	148.77	74.4
	62	442.18	7.91	450.09	225.0	200.47	100.2	292.56	146.3	152.69	76.3
	63	453.38	7.91	461.29	230.6	205.50	102.8	299.84	149.9	156.61	78.3
	64	464.58	7.91	472.49	236.2	210.54	105.3	307.12	153.6	160.53	80.3
	65	476.51	7.91	484.42	242.2	215.91	108.0	314.87	157.4	164.70	82.4
	66	488.64	7.91	496.55	248.3	221.37	110.7	322.76	161.4	168.95	84.5
	67	500.77	7.91	508.68	254.3	226.83	113.4	330.64	165.3	173.19	86.6
	68	512.90	7.91	520.81	260.4	232.29	116.1	338.53	169.3	177.44	88.7
	69	525.03	7.91	532.94	266.5	237.75	118.9	346.41	173.2	181.68	90.8
	70	537.16	7.91	545.07	272.5	243.21	121.6	354.30	177.1	185.93	93.0
	71	549.29	7.91	557.20	278.6	248.66	124.3	362.18	181.1	190.18	95.1
	72	561.42	7.91	569.33	284.7	254.12	127.1	370.07	185.0	194.42	97.2
	73	573.55	7.91	581.46	290.7	259.58	129.8	377.95	189.0	198.67	99.3
	74	586.42	7.91	594.33	297.2	265.37	132.7	386.31	193.2	203.17	101.6
	75	599.48	7.91	607.39	303.7	271.25	135.6	394.80	197.4	207.74	103.9
	76	612.54	7.91	620.45	310.2	277.13	138.6	403.29	201.6	212.31	106.2
	77	625.61	7.91	633.52	316.8	283.01	141.5	411.79	205.9	216.89	108.4
	78	638.67	7.91	646.58	323.3	288.88	144.4	420.28	210.1	221.46	110.7
	79	651.73	7.91	659.64	329.8	294.76	147.4	428.77	214.4	226.03	113.0
	80	664.79	7.91	672.70	336.4	300.64	150.3	437.26	218.6	230.60	115.3

<u>Steel H-Pile Capacities</u>
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
14x73 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	**ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65) (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method (kips)**	**(tons)**
	1	2.92	1.00	3.92	2.0	**1.37**	**0.7**	**2.55**	**1.3**	**0.73**	**0.4**
	2	5.85	1.00	6.85	3.4	**2.40**	**1.2**	**4.45**	**2.2**	**1.46**	**0.7**
	3	8.77	1.00	9.77	4.9	**3.42**	**1.7**	**6.35**	**3.2**	**2.19**	**1.1**
	4	11.70	1.00	12.70	6.3	**4.44**	**2.2**	**8.25**	**4.1**	**2.92**	**1.5**
	5	14.62	1.00	15.62	7.8	**5.47**	**2.7**	**10.16**	**5.1**	**3.66**	**1.8**
	6	17.55	1.00	18.55	9.3	**6.49**	**3.2**	**12.06**	**6.0**	**4.39**	**2.2**
	7	20.47	1.00	21.47	10.7	**7.52**	**3.8**	**13.96**	**7.0**	**5.12**	**2.6**
	8	23.40	1.00	24.40	12.2	**8.54**	**4.3**	**15.86**	**7.9**	**5.85**	**2.9**
Clay	8.4	24.58	1.00	25.58	12.8	**8.95**	**4.5**	**16.62**	**8.3**	**6.14**	**3.1**
Sand	8.4	24.58	9.33	33.91	17.0	**12.80**	**6.4**	**22.04**	**11.0**	**6.14**	**3.1**
	9	27.64	10.93	38.57	19.3	**14.90**	**7.5**	**25.07**	**12.5**	**7.22**	**3.6**
	10	32.78	10.93	43.71	21.9	**17.21**	**8.6**	**28.41**	**14.2**	**9.02**	**4.5**
	11	37.93	10.93	48.86	24.4	**19.53**	**9.8**	**31.76**	**15.9**	**10.82**	**5.4**
	12	43.07	10.93	54.00	27.0	**21.84**	**10.9**	**35.10**	**17.5**	**12.62**	**6.3**
	13	48.21	10.93	59.14	29.6	**24.15**	**12.1**	**38.44**	**19.2**	**14.42**	**7.2**
	14	53.35	10.93	64.28	32.1	**26.47**	**13.2**	**41.78**	**20.9**	**16.21**	**8.1**
	15	58.49	10.93	69.42	34.7	**28.78**	**14.4**	**45.12**	**22.6**	**18.01**	**9.0**
	16	63.63	10.93	74.56	37.3	**31.09**	**15.5**	**48.46**	**24.2**	**19.81**	**9.9**
	17	68.77	10.93	79.70	39.9	**33.41**	**16.7**	**51.81**	**25.9**	**21.61**	**10.8**
	18	75.41	10.93	86.34	43.2	**36.40**	**18.2**	**56.12**	**28.1**	**23.94**	**12.0**
	19	83.09	10.93	94.02	47.0	**39.85**	**19.9**	**61.11**	**30.6**	**26.62**	**13.3**
	20	90.76	10.93	101.69	50.8	**43.30**	**21.7**	**66.10**	**33.1**	**29.31**	**14.7**
	21	98.44	10.93	109.37	54.7	**46.76**	**23.4**	**71.09**	**35.5**	**32.00**	**16.0**
	22	106.12	10.93	117.05	58.5	**50.21**	**25.1**	**76.08**	**38.0**	**34.68**	**17.3**
	23	113.79	10.93	124.72	62.4	**53.67**	**26.8**	**81.07**	**40.5**	**37.37**	**18.7**
	24	121.47	10.93	132.40	66.2	**57.12**	**28.6**	**86.06**	**43.0**	**40.06**	**20.0**
	25	129.15	10.93	140.08	70.0	**60.58**	**30.3**	**91.05**	**45.5**	**42.74**	**21.4**
	26	136.82	10.93	147.75	73.9	**64.03**	**32.0**	**96.04**	**48.0**	**45.43**	**22.7**
	27	146.00	10.93	156.93	78.5	**68.16**	**34.1**	**102.00**	**51.0**	**48.64**	**24.3**
	28	156.21	10.93	167.14	83.6	**72.76**	**36.4**	**108.64**	**54.3**	**52.22**	**26.1**
	29	166.43	10.93	177.36	88.7	**77.35**	**38.7**	**115.28**	**57.6**	**55.79**	**27.9**
	30	176.64	10.93	187.57	93.8	**81.95**	**41.0**	**121.92**	**61.0**	**59.37**	**29.7**
	31	186.85	10.93	197.78	98.9	**86.55**	**43.3**	**128.56**	**64.3**	**62.94**	**31.5**
	32	197.07	10.93	208.00	104.0	**91.14**	**45.6**	**135.20**	**67.6**	**66.52**	**33.3**
	33	207.28	10.93	218.21	109.1	**95.74**	**47.9**	**141.84**	**70.9**	**70.09**	**35.0**
	34	217.50	10.93	228.43	114.2	**100.33**	**50.2**	**148.48**	**74.2**	**73.67**	**36.8**
	35	227.71	10.93	238.64	119.3	**104.93**	**52.5**	**155.12**	**77.6**	**77.24**	**38.6**
	36	238.82	10.93	249.75	124.9	**109.93**	**55.0**	**162.34**	**81.2**	**81.13**	**40.6**
@ 37.2'	37	250.55	10.93	261.48	130.7	**115.21**	**57.6**	**169.96**	**85.0**	**85.24**	**42.6**
	38	262.99	10.93	273.92	137.0	**120.81**	**60.4**	**178.05**	**89.0**	**89.59**	**44.8**
	39	275.61	10.93	286.54	143.3	**126.48**	**63.2**	**186.25**	**93.1**	**94.01**	**47.0**

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
14x73 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
Sand	40	288.23	10.93	299.16	149.6	132.16	66.1	194.45	97.2	98.42	49.2
	41	300.85	10.93	311.78	155.9	137.84	68.9	202.65	101.3	102.84	51.4
	42	313.46	10.93	324.39	162.2	143.52	71.8	210.86	105.4	107.26	53.6
	43	326.08	10.93	337.01	168.5	149.20	74.6	219.06	109.5	111.67	55.8
	44	338.70	10.93	349.63	174.8	154.88	77.4	227.26	113.6	116.09	58.0
	45	351.32	10.93	362.25	181.1	160.56	80.3	235.46	117.7	120.50	60.3
	46	363.94	10.93	374.87	187.4	166.23	83.1	243.67	121.8	124.92	62.5
	47	377.55	10.93	388.48	194.2	172.36	86.2	252.51	126.3	129.69	64.8
	48	391.43	10.93	402.36	201.2	178.61	89.3	261.53	130.8	134.54	67.3
	49	405.31	10.93	416.24	208.1	184.85	92.4	270.56	135.3	139.40	69.7
	50	419.19	10.93	430.12	215.1	191.10	95.5	279.58	139.8	144.26	72.1
	51	433.06	10.93	443.99	222.0	197.34	98.7	288.60	144.3	149.12	74.6
	52	446.94	10.93	457.87	228.9	203.59	101.8	297.62	148.8	153.97	77.0
	53	460.82	10.93	471.75	235.9	209.83	104.9	306.64	153.3	158.83	79.4
	54	474.70	10.93	485.63	242.8	216.08	108.0	315.66	157.8	163.69	81.8
	55	488.58	10.93	499.51	249.8	222.32	111.2	324.68	162.3	168.54	84.3
	56	503.45	10.93	514.38	257.2	229.01	114.5	334.35	167.2	173.75	86.9
	57	518.59	10.93	529.52	264.8	235.83	117.9	344.19	172.1	179.05	89.5
	58	533.73	10.93	544.66	272.3	242.64	121.3	354.03	177.0	184.35	92.2
	59	548.87	10.93	559.80	279.9	249.45	124.7	363.87	181.9	189.65	94.8
	60	564.01	10.93	574.94	287.5	256.26	128.1	373.71	186.9	194.94	97.5
	61	579.14	10.93	590.07	295.0	263.08	131.5	383.55	191.8	200.24	100.1
	62	594.28	10.93	605.21	302.6	269.89	134.9	393.39	196.7	205.54	102.8
	63	609.42	10.93	620.35	310.2	276.70	138.4	403.23	201.6	210.84	105.4
	64	624.56	10.93	635.49	317.7	283.51	141.8	413.07	206.5	216.14	108.1
	65	640.69	10.93	651.62	325.8	290.77	145.4	423.56	211.8	221.79	110.9
	66	657.09	10.93	668.02	334.0	298.15	149.1	434.21	217.1	227.52	113.8
	67	673.49	10.93	684.42	342.2	305.53	152.8	444.87	222.4	233.26	116.6
	68	689.89	10.93	700.82	350.4	312.91	156.5	455.53	227.8	239.00	119.5
	69	706.29	10.93	717.22	358.6	320.29	160.1	466.19	233.1	244.74	122.4
	70	722.68	10.93	733.61	366.8	327.67	163.8	476.85	238.4	250.48	125.2
	71	739.08	10.93	750.01	375.0	335.05	167.5	487.51	243.8	256.22	128.1
	72	755.48	10.93	766.41	383.2	342.43	171.2	498.17	249.1	261.96	131.0
	73	771.88	10.93	782.81	391.4	349.81	174.9	508.82	254.4	267.70	133.8
	74	789.27	10.93	800.20	400.1	357.63	178.8	520.13	260.1	273.79	136.9
	75	806.93	10.93	817.86	408.9	365.58	182.8	531.61	265.8	279.97	140.0
	76	824.59	10.93	835.52	417.8	373.53	186.8	543.09	271.5	286.15	143.1
	77	842.25	10.93	853.18	426.6	381.47	190.7	554.57	277.3	292.33	146.2
	78	859.91	10.93	870.84	435.4	389.42	194.7	566.04	283.0	298.51	149.3
	79	877.56	10.93	888.49	444.2	397.37	198.7	577.52	288.8	304.69	152.3
	80	895.22	10.93	906.15	453.1	405.31	202.7	589.00	294.5	310.87	155.4

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
14x89 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method (kips)	(tons)	ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65) (kips)	(tons)	ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method (kips)	(tons)
	1	2.96	1.22	4.18	2.1	1.46	0.7	2.72	1.4	0.74	0.4
	2	5.92	1.22	7.14	3.6	2.50	1.2	4.64	2.3	1.48	0.7
	3	8.88	1.22	10.10	5.0	3.53	1.8	6.56	3.3	2.22	1.1
	4	11.83	1.22	13.05	6.5	4.57	2.3	8.49	4.2	2.96	1.5
	5	14.79	1.22	16.01	8.0	5.61	2.8	10.41	5.2	3.70	1.8
	6	17.75	1.22	18.97	9.5	6.64	3.3	12.33	6.2	4.44	2.2
	7	20.72	1.22	21.94	11.0	7.68	3.8	14.26	7.1	5.18	2.6
	8	23.68	1.22	24.90	12.4	8.71	4.4	16.18	8.1	5.92	3.0
Clay	8.4	24.87	1.22	26.09	13.0	9.13	4.6	16.96	8.5	6.22	3.1
Sand	8.4	24.87	11.38	36.25	18.1	13.82	6.9	23.56	11.8	6.22	3.1
	9	28.24	13.33	41.57	20.8	16.22	8.1	27.02	13.5	7.40	3.7
	10	33.91	13.33	47.24	23.6	18.77	9.4	30.70	15.4	9.38	4.7
	11	39.57	13.33	52.90	26.5	21.32	10.7	34.39	17.2	11.36	5.7
	12	45.24	13.33	58.57	29.3	23.87	11.9	38.07	19.0	13.35	6.7
	13	50.90	13.33	64.23	32.1	26.42	13.2	41.75	20.9	15.33	7.7
	14	56.57	13.33	69.90	35.0	28.97	14.5	45.44	22.7	17.31	8.7
	15	62.24	13.33	75.57	37.8	31.52	15.8	49.12	24.6	19.30	9.6
	16	67.90	13.33	81.23	40.6	34.07	17.0	52.80	26.4	21.28	10.6
	17	73.57	13.33	86.90	43.4	36.62	18.3	56.48	28.2	23.26	11.6
	18	80.88	13.33	94.21	47.1	39.91	20.0	61.24	30.6	25.82	12.9
	19	89.34	13.33	102.67	51.3	43.72	21.9	66.74	33.4	28.78	14.4
	20	97.80	13.33	111.13	55.6	47.52	23.8	72.24	36.1	31.74	15.9
	21	106.27	13.33	119.60	59.8	51.33	25.7	77.74	38.9	34.71	17.4
	22	114.73	13.33	128.06	64.0	55.14	27.6	83.24	41.6	37.67	18.8
	23	123.19	13.33	136.52	68.3	58.95	29.5	88.74	44.4	40.63	20.3
	24	131.65	13.33	144.98	72.5	62.75	31.4	94.24	47.1	43.59	21.8
	25	140.11	13.33	153.44	76.7	66.56	33.3	99.74	49.9	46.55	23.3
	26	148.57	13.33	161.90	81.0	70.37	35.2	105.24	52.6	49.51	24.8
	27	158.68	13.33	172.01	86.0	74.92	37.5	111.81	55.9	53.05	26.5
	28	169.94	13.33	183.27	91.6	79.98	40.0	119.12	59.6	56.99	28.5
	29	181.19	13.33	194.52	97.3	85.05	42.5	126.44	63.2	60.93	30.5
	30	192.45	13.33	205.78	102.9	90.12	45.1	133.76	66.9	64.87	32.4
	31	203.71	13.33	217.04	108.5	95.18	47.6	141.07	70.5	68.81	34.4
	32	214.96	13.33	228.29	114.1	100.25	50.1	148.39	74.2	72.75	36.4
	33	226.22	13.33	239.55	119.8	105.31	52.7	155.71	77.9	76.69	38.3
	34	237.48	13.33	250.81	125.4	110.38	55.2	163.03	81.5	80.63	40.3
	35	248.73	13.33	262.06	131.0	115.44	57.7	170.34	85.2	84.57	42.3
	36	260.98	13.33	274.31	137.2	120.95	60.5	178.30	89.2	88.86	44.4
@ 37.2'	37	273.91	13.33	287.24	143.6	126.77	63.4	186.71	93.4	93.38	46.7
	38	287.62	13.33	300.95	150.5	132.94	66.5	195.62	97.8	98.18	49.1
	39	301.52	13.33	314.85	157.4	139.20	69.6	204.65	102.3	103.05	51.5

Steel H-Pile Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
14x89 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		ϕR_n Total Factored Geotechnical Axial Resistance Static Analysis Method		ϕR_n Total Factored Geotechnical Axial Resistance Dynamic Analysis Method (ϕ=0.65)		ϕR_n Total Factored Geotechnical Uplift Resistance Static Analysis Method	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)	(kips)	(tons)
Sand	40	315.43	13.33	328.76	164.4	145.46	72.7	213.69	106.8	107.91	54.0
	41	329.34	13.33	342.67	171.3	151.71	75.9	222.73	111.4	112.78	56.4
	42	343.24	13.33	356.57	178.3	157.97	79.0	231.77	115.9	117.65	58.8
	43	357.15	13.33	370.48	185.2	164.23	82.1	240.81	120.4	122.52	61.3
	44	371.06	13.33	384.39	192.2	170.49	85.2	249.85	124.9	127.38	63.7
	45	384.96	13.33	398.29	199.1	176.75	88.4	258.89	129.4	132.25	66.1
	46	398.87	13.33	412.20	206.1	183.00	91.5	267.93	134.0	137.12	68.6
	47	413.87	13.33	427.20	213.6	189.76	94.9	277.68	138.8	142.37	71.2
	48	429.17	13.33	442.50	221.2	196.64	98.3	287.62	143.8	147.72	73.9
	49	444.46	13.33	457.79	228.9	203.52	101.8	297.57	148.8	153.08	76.5
	50	459.76	13.33	473.09	236.5	210.40	105.2	307.51	153.8	158.43	79.2
	51	475.06	13.33	488.39	244.2	217.29	108.6	317.45	158.7	163.78	81.9
	52	490.35	13.33	503.68	251.8	224.17	112.1	327.39	163.7	169.14	84.6
	53	505.65	13.33	518.98	259.5	231.05	115.5	337.33	168.7	174.49	87.2
	54	520.94	13.33	534.27	267.1	237.94	119.0	347.28	173.6	179.84	89.9
	55	536.24	13.33	549.57	274.8	244.82	122.4	357.22	178.6	185.20	92.6
	56	552.63	13.33	565.96	283.0	252.20	126.1	367.87	183.9	190.93	95.5
	57	569.32	13.33	582.65	291.3	259.70	129.9	378.72	189.4	196.77	98.4
	58	586.00	13.33	599.33	299.7	267.21	133.6	389.56	194.8	202.61	101.3
	59	602.68	13.33	616.01	308.0	274.72	137.4	400.41	200.2	208.45	104.2
	60	619.37	13.33	632.70	316.3	282.23	141.1	411.25	205.6	214.29	107.1
	61	636.05	13.33	649.38	324.7	289.74	144.9	422.10	211.0	220.13	110.1
	62	652.74	13.33	666.07	333.0	297.24	148.6	432.94	216.5	225.97	113.0
	63	669.42	13.33	682.75	341.4	304.75	152.4	443.79	221.9	231.81	115.9
	64	686.11	13.33	699.44	349.7	312.26	156.1	454.63	227.3	237.65	118.8
	65	703.89	13.33	717.22	358.6	320.26	160.1	466.19	233.1	243.87	121.9
	66	721.96	13.33	735.29	367.6	328.39	164.2	477.94	239.0	250.20	125.1
	67	740.03	13.33	753.36	376.7	336.53	168.3	489.68	244.8	256.52	128.3
	68	758.10	13.33	771.43	385.7	344.66	172.3	501.43	250.7	262.85	131.4
	69	776.18	13.33	789.51	394.8	352.79	176.4	513.18	256.6	269.18	134.6
	70	794.25	13.33	807.58	403.8	360.92	180.5	524.93	262.5	275.50	137.8
	71	812.32	13.33	825.65	412.8	369.06	184.5	536.67	268.3	281.83	140.9
	72	830.39	13.33	843.72	421.9	377.19	188.6	548.42	274.2	288.15	144.1
	73	848.46	13.33	861.79	430.9	385.32	192.7	560.17	280.1	294.48	147.2
	74	867.64	13.33	880.97	440.5	393.95	197.0	572.63	286.3	301.19	150.6
	75	887.10	13.33	900.43	450.2	402.71	201.4	585.28	292.6	308.00	154.0
	76	906.56	13.33	919.89	459.9	411.46	205.7	597.93	299.0	314.81	157.4
	77	926.02	13.33	939.35	469.7	420.22	210.1	610.58	305.3	321.62	160.8
	78	945.48	13.33	958.81	479.4	428.98	214.5	623.23	311.6	328.43	164.2
	79	964.95	13.33	978.28	489.1	437.74	218.9	635.88	317.9	335.24	167.6
	80	984.41	13.33	997.74	498.9	446.50	223.2	648.53	324.3	342.06	171.0

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
30-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Below Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
	1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	3	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	4	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	5	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	6	3.24	40.70	43.94	22.0	1.46	16.28	**17.74**	**8.9**	**1.13**	**0.6**
	7	6.48	44.94	51.42	25.7	2.92	17.98	**20.89**	**10.4**	**2.27**	**1.1**
Clay	8	9.72	49.14	58.86	29.4	4.37	19.66	**24.03**	**12.0**	**3.40**	**1.7**
Sand	9	19.60	53.32	72.92	36.5	9.81	26.66	**36.47**	**18.2**	**7.85**	**3.9**
	10	30.32	57.52	87.84	43.9	15.70	28.76	**44.46**	**22.2**	**12.67**	**6.3**
	11	41.86	61.70	103.56	51.8	22.05	30.85	**52.90**	**26.5**	**17.87**	**8.9**
	12	54.18	65.90	120.08	60.0	28.83	32.95	**61.78**	**30.9**	**23.41**	**11.7**
	13	67.26	70.08	137.34	68.7	36.02	35.04	**71.06**	**35.5**	**29.30**	**14.6**
	14	81.08	74.28	155.36	77.7	43.62	37.14	**80.76**	**40.4**	**35.51**	**17.8**
	15	95.60	78.46	174.06	87.0	51.61	39.23	**90.84**	**45.4**	**42.05**	**21.0**
	16	110.80	82.66	193.46	96.7	59.97	41.33	**101.30**	**50.6**	**48.89**	**24.4**
	17	126.66	86.84	213.50	106.8	68.69	43.42	**112.11**	**56.1**	**56.03**	**28.0**
	18	143.16	91.04	234.20	117.1	77.77	45.52	**123.29**	**61.6**	**63.45**	**31.7**
	19	160.26	95.22	255.48	127.7	87.17	47.61	**134.78**	**67.4**	**71.15**	**35.6**
	20	177.94	99.42	277.36	138.7	96.90	49.71	**146.61**	**73.3**	**79.10**	**39.6**
	21	196.18	102.46	298.64	149.3	106.93	51.23	**158.16**	**79.1**	**87.31**	**43.7**
	22	214.98	104.18	319.16	159.6	117.27	52.09	**169.36**	**84.7**	**95.77**	**47.9**
	23	234.30	104.74	339.04	169.5	127.89	52.37	**180.26**	**90.1**	**104.46**	**52.2**
	24	254.10	104.74	358.84	179.4	138.78	52.37	**191.15**	**95.6**	**113.37**	**56.7**
	25	274.40	104.74	379.14	189.6	149.95	52.37	**202.32**	**101.2**	**122.51**	**61.3**
	26	295.16	104.74	399.90	200.0	161.37	52.37	**213.74**	**106.9**	**131.85**	**65.9**
	27	316.36	104.74	421.10	210.6	173.03	52.37	**225.40**	**112.7**	**141.39**	**70.7**
	28	337.98	104.74	442.72	221.4	184.92	52.37	**237.29**	**118.6**	**151.12**	**75.6**
	29	360.02	104.74	464.76	232.4	197.04	52.37	**249.41**	**124.7**	**161.04**	**80.5**
	30	382.44	104.74	487.18	243.6	209.37	52.37	**261.74**	**130.9**	**171.13**	**85.6**
	31	405.22	104.74	509.96	255.0	221.90	52.37	**274.27**	**137.1**	**181.38**	**90.7**
	32	428.36	104.74	533.10	266.6	234.63	52.37	**287.00**	**143.5**	**191.79**	**95.9**
	33	451.82	104.74	556.56	278.3	247.53	52.37	**299.90**	**149.9**	**202.35**	**101.2**
	34	475.60	104.74	580.34	290.2	260.61	52.37	**312.98**	**156.5**	**213.05**	**106.5**
	35	499.70	104.74	604.44	302.2	273.86	52.37	**326.23**	**163.1**	**223.89**	**111.9**
	36	524.06	104.74	628.80	314.4	287.26	52.37	**339.63**	**169.8**	**234.86**	**117.4**
@ 37.2'	37	548.70	104.74	653.44	326.7	300.81	52.37	**353.18**	**176.6**	**245.94**	**123.0**
	38	573.26	104.74	678.00	339.0	314.32	52.37	**366.69**	**183.3**	**257.00**	**128.5**
	39	597.72	104.74	702.46	351.2	327.77	52.37	**380.14**	**190.1**	**268.00**	**134.0**
	40	622.12	104.74	726.86	363.4	341.19	52.37	**393.56**	**196.8**	**278.98**	**139.5**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
30-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Below Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
Sand	41	646.42	104.74	751.16	375.6	354.56	52.37	**406.93**	**203.5**	**289.92**	**145.0**
	42	670.60	104.74	775.34	387.7	367.86	52.37	**420.23**	**210.1**	**300.80**	**150.4**
	43	694.70	104.74	799.44	399.7	381.11	52.37	**433.48**	**216.7**	**311.64**	**155.8**
	44	718.68	104.74	823.42	411.7	394.30	52.37	**446.67**	**223.3**	**322.43**	**161.2**
	45	742.56	104.74	847.30	423.7	407.44	52.37	**459.81**	**229.9**	**333.18**	**166.6**
	46	766.32	104.74	871.06	435.5	420.50	52.37	**472.87**	**236.4**	**343.87**	**171.9**
	47	789.94	104.74	894.68	447.3	433.50	52.37	**485.87**	**242.9**	**354.50**	**177.3**
	48	813.44	104.74	918.18	459.1	446.42	52.37	**498.79**	**249.4**	**365.08**	**182.5**
	49	836.80	104.74	941.54	470.8	459.27	52.37	**511.64**	**255.8**	**375.59**	**187.8**
	50	860.02	104.74	964.76	482.4	472.04	52.37	**524.41**	**262.2**	**386.04**	**193.0**
	51	883.10	104.74	987.84	493.9	484.73	52.37	**537.10**	**268.6**	**396.42**	**198.2**
	52	906.04	104.74	1010.78	505.4	497.35	52.37	**549.72**	**274.9**	**406.75**	**203.4**
	53	928.80	104.74	1033.54	516.8	509.87	52.37	**562.24**	**281.1**	**416.99**	**208.5**
	54	951.42	104.74	1056.16	528.1	522.31	52.37	**574.68**	**287.3**	**427.17**	**213.6**
	55	973.86	104.74	1078.60	539.3	534.65	52.37	**587.02**	**293.5**	**437.27**	**218.6**
	56	996.14	104.74	1100.88	550.4	546.91	52.37	**599.28**	**299.6**	**447.29**	**223.6**
	57	1018.24	104.74	1122.98	561.5	559.06	52.37	**611.43**	**305.7**	**457.24**	**228.6**
	58	1040.16	104.74	1144.90	572.5	571.12	52.37	**623.49**	**311.7**	**467.10**	**233.6**
	59	1061.88	104.74	1166.62	583.3	583.06	52.37	**635.43**	**317.7**	**476.87**	**238.4**
	60	1083.44	104.74	1188.18	594.1	594.92	52.37	**647.29**	**323.6**	**486.58**	**243.3**
	61	1104.78	104.74	1209.52	604.8	606.66	52.37	**659.03**	**329.5**	**496.18**	**248.1**
	62	1125.92	104.74	1230.66	615.3	618.28	52.37	**670.65**	**335.3**	**505.69**	**252.8**
	63	1146.86	104.74	1251.60	625.8	629.80	52.37	**682.17**	**341.1**	**515.12**	**257.6**
	64	1167.60	104.74	1272.34	636.2	641.21	52.37	**693.58**	**346.8**	**524.45**	**262.2**
	65	1188.10	104.74	1292.84	646.4	652.48	52.37	**704.85**	**352.4**	**533.67**	**266.8**
	66	1208.40	104.74	1313.14	656.6	663.65	52.37	**716.02**	**358.0**	**542.81**	**271.4**
	67	1228.46	104.74	1333.20	666.6	674.68	52.37	**727.05**	**363.5**	**551.84**	**275.9**
	68	1248.30	104.74	1353.04	676.5	685.59	52.37	**737.96**	**369.0**	**560.76**	**280.4**
	69	1267.90	104.74	1372.64	686.3	696.37	52.37	**748.74**	**374.4**	**569.58**	**284.8**
	70	1287.26	104.74	1392.00	696.0	707.02	52.37	**759.39**	**379.7**	**578.30**	**289.1**
	71	1306.38	104.74	1411.12	705.6	717.54	52.37	**769.91**	**385.0**	**586.90**	**293.4**
	72	1325.26	104.74	1430.00	715.0	727.92	52.37	**780.29**	**390.1**	**595.40**	**297.7**
	73	1343.86	104.74	1448.60	724.3	738.15	52.37	**790.52**	**395.3**	**603.77**	**301.9**
	74	1362.22	104.74	1466.96	733.5	748.25	52.37	**800.62**	**400.3**	**612.03**	**306.0**
	75	1380.32	104.74	1485.06	742.5	758.20	52.37	**810.57**	**405.3**	**620.17**	**310.1**
	76	1398.14	104.74	1502.88	751.4	768.01	52.37	**820.38**	**410.2**	**628.19**	**314.1**
	77	1415.68	104.74	1520.42	760.2	777.65	52.37	**830.02**	**415.0**	**636.08**	**318.0**
	78	1432.96	104.74	1537.70	768.9	787.16	52.37	**839.53**	**419.8**	**643.86**	**321.9**
	79	1449.94	104.74	1554.68	777.3	796.50	52.37	**848.87**	**424.4**	**651.50**	**325.8**
	80	1466.64	104.74	1571.38	785.7	805.68	52.37	**858.05**	**429.0**	**659.02**	**329.5**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
36-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Below Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
	1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	3	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	4	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	5	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	6	3.88	52.48	56.36	28.2	1.75	20.99	**22.74**	**11.4**	**1.36**	**0.7**
	7	7.78	56.82	64.60	32.3	3.50	22.73	**26.23**	**13.1**	**2.72**	**1.4**
Clay	8	11.66	61.86	73.52	36.8	5.25	24.74	**29.99**	**15.0**	**4.08**	**2.0**
Sand	9	23.52	66.88	90.40	45.2	11.77	33.44	**45.21**	**22.6**	**9.42**	**4.7**
	10	36.38	71.92	108.30	54.2	18.84	35.96	**54.80**	**27.4**	**15.21**	**7.6**
	11	50.22	76.94	127.16	63.6	26.46	38.47	**64.93**	**32.5**	**21.43**	**10.7**
	12	65.02	81.96	146.98	73.5	34.60	40.98	**75.58**	**37.8**	**28.09**	**14.0**
	13	80.72	87.00	167.72	83.9	43.23	43.50	**86.73**	**43.4**	**35.16**	**17.6**
	14	97.30	92.02	189.32	94.7	52.35	46.01	**98.36**	**49.2**	**42.62**	**21.3**
	15	114.72	97.06	211.78	105.9	61.93	48.53	**110.46**	**55.2**	**50.46**	**25.2**
	16	132.96	102.08	235.04	117.5	71.96	51.04	**123.00**	**61.5**	**58.67**	**29.3**
	17	152.00	107.10	259.10	129.6	82.43	53.55	**135.98**	**68.0**	**67.23**	**33.6**
	18	171.78	112.14	283.92	142.0	93.31	56.07	**149.38**	**74.7**	**76.14**	**38.1**
	19	192.30	117.16	309.46	154.7	104.60	58.58	**163.18**	**81.6**	**85.37**	**42.7**
	20	213.52	122.20	335.72	167.9	116.27	61.10	**177.37**	**88.7**	**94.92**	**47.5**
	21	235.42	127.22	362.64	181.3	128.32	63.61	**191.93**	**96.0**	**104.77**	**52.4**
	22	257.98	132.24	390.22	195.1	140.72	66.12	**206.84**	**103.4**	**114.93**	**57.5**
	23	281.16	137.28	418.44	209.2	153.47	68.64	**222.11**	**111.1**	**125.36**	**62.7**
	24	304.92	142.30	447.22	223.6	166.54	71.15	**237.69**	**118.8**	**136.05**	**68.0**
	25	329.28	146.26	475.54	237.8	179.94	73.13	**253.07**	**126.5**	**147.01**	**73.5**
	26	354.20	149.00	503.20	251.6	193.64	74.50	**268.14**	**134.1**	**158.22**	**79.1**
	27	379.64	150.38	530.02	265.0	207.64	75.19	**282.83**	**141.4**	**169.67**	**84.8**
	28	405.58	150.84	556.42	278.2	221.90	75.42	**297.32**	**148.7**	**181.35**	**90.7**
	29	432.02	150.84	582.86	291.4	236.45	75.42	**311.87**	**155.9**	**193.24**	**96.6**
	30	458.92	150.84	609.76	304.9	251.24	75.42	**326.66**	**163.3**	**205.35**	**102.7**
	31	486.26	150.84	637.10	318.6	266.28	75.42	**341.70**	**170.8**	**217.65**	**108.8**
	32	514.02	150.84	664.86	332.4	281.55	75.42	**356.97**	**178.5**	**230.14**	**115.1**
	33	542.18	150.84	693.02	346.5	297.03	75.42	**372.45**	**186.2**	**242.82**	**121.4**
	34	570.72	150.84	721.56	360.8	312.73	75.42	**388.15**	**194.1**	**255.66**	**127.8**
	35	599.62	150.84	750.46	375.2	328.63	75.42	**404.05**	**202.0**	**268.66**	**134.3**
	36	628.88	150.84	779.72	389.9	344.72	75.42	**420.14**	**210.1**	**281.83**	**140.9**
@ 37.2'	37	658.44	150.84	809.28	404.6	360.98	75.42	**436.40**	**218.2**	**295.13**	**147.6**
	38	687.90	150.84	838.74	419.4	377.18	75.42	**452.60**	**226.3**	**308.39**	**154.2**
	39	717.28	150.84	868.12	434.1	393.34	75.42	**468.76**	**234.4**	**321.61**	**160.8**
	40	746.54	150.84	897.38	448.7	409.43	75.42	**484.85**	**242.4**	**334.78**	**167.4**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
36-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Below Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		Factored Nominal Side Resistance	Factored Nominal End Bearing	**ϕR_n Total Factored Geotechnical Axial Resistance**		**ϕR_n Total Factored Geotechnical Uplift Resistance**	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(kips)	**(kips)**	**(tons)**	**(kips)**	**(tons)**
Sand	41	775.70	150.84	926.54	463.3	425.47	75.42	**500.89**	**250.4**	**347.90**	**173.9**
	42	804.72	150.84	955.56	477.8	441.43	75.42	**516.85**	**258.4**	**360.96**	**180.5**
	43	833.64	150.84	984.48	492.2	457.34	75.42	**532.76**	**266.4**	**373.97**	**187.0**
	44	862.42	150.84	1013.26	506.6	473.17	75.42	**548.59**	**274.3**	**386.92**	**193.5**
	45	891.08	150.84	1041.92	521.0	488.93	75.42	**564.35**	**282.2**	**399.82**	**199.9**
	46	919.58	150.84	1070.42	535.2	504.60	75.42	**580.02**	**290.0**	**412.65**	**206.3**
	47	947.92	150.84	1098.76	549.4	520.19	75.42	**595.61**	**297.8**	**425.40**	**212.7**
	48	976.12	150.84	1126.96	563.5	535.70	75.42	**611.12**	**305.6**	**438.09**	**219.0**
	49	1004.16	150.84	1155.00	577.5	551.12	75.42	**626.54**	**313.3**	**450.71**	**225.4**
	50	1032.02	150.84	1182.86	591.4	566.45	75.42	**641.87**	**320.9**	**463.24**	**231.6**
	51	1059.72	150.84	1210.56	605.3	581.68	75.42	**657.10**	**328.6**	**475.71**	**237.9**
	52	1087.24	150.84	1238.08	619.0	596.82	75.42	**672.24**	**336.1**	**488.09**	**244.0**
	53	1114.56	150.84	1265.40	632.7	611.84	75.42	**687.26**	**343.6**	**500.39**	**250.2**
	54	1141.70	150.84	1292.54	646.3	626.77	75.42	**702.19**	**351.1**	**512.60**	**256.3**
	55	1168.64	150.84	1319.48	659.7	641.59	75.42	**717.01**	**358.5**	**524.72**	**262.4**
	56	1195.36	150.84	1346.20	673.1	656.28	75.42	**731.70**	**365.9**	**536.75**	**268.4**
	57	1221.88	150.84	1372.72	686.4	670.87	75.42	**746.29**	**373.1**	**548.68**	**274.3**
	58	1248.18	150.84	1399.02	699.5	685.33	75.42	**760.75**	**380.4**	**560.52**	**280.3**
	59	1274.26	150.84	1425.10	712.6	699.68	75.42	**775.10**	**387.5**	**572.25**	**286.1**
	60	1300.12	150.84	1450.96	725.5	713.90	75.42	**789.32**	**394.7**	**583.89**	**291.9**
	61	1325.74	150.84	1476.58	738.3	727.99	75.42	**803.41**	**401.7**	**595.42**	**297.7**
	62	1351.10	150.84	1501.94	751.0	741.94	75.42	**817.36**	**408.7**	**606.83**	**303.4**
	63	1376.24	150.84	1527.08	763.5	755.77	75.42	**831.19**	**415.6**	**618.14**	**309.1**
	64	1401.12	150.84	1551.96	776.0	769.45	75.42	**844.87**	**422.4**	**629.34**	**314.7**
	65	1425.72	150.84	1576.56	788.3	782.98	75.42	**858.40**	**429.2**	**640.41**	**320.2**
	66	1450.08	150.84	1600.92	800.5	796.38	75.42	**871.80**	**435.9**	**651.37**	**325.7**
	67	1474.16	150.84	1625.00	812.5	809.62	75.42	**885.04**	**442.5**	**662.21**	**331.1**
	68	1497.96	150.84	1648.80	824.4	822.71	75.42	**898.13**	**449.1**	**672.92**	**336.5**
	69	1521.48	150.84	1672.32	836.2	835.65	75.42	**911.07**	**455.5**	**683.50**	**341.8**
	70	1544.72	150.84	1695.56	847.8	848.43	75.42	**923.85**	**461.9**	**693.96**	**347.0**
	71	1567.66	150.84	1718.50	859.3	861.05	75.42	**936.47**	**468.2**	**704.28**	**352.1**
	72	1590.30	150.84	1741.14	870.6	873.50	75.42	**948.92**	**474.5**	**714.47**	**357.2**
	73	1612.64	150.84	1763.48	881.7	885.79	75.42	**961.21**	**480.6**	**724.52**	**362.3**
	74	1634.66	150.84	1785.50	892.8	897.90	75.42	**973.32**	**486.7**	**734.43**	**367.2**
	75	1656.38	150.84	1807.22	903.6	909.84	75.42	**985.26**	**492.6**	**744.21**	**372.1**
	76	1677.76	150.84	1828.60	914.3	921.60	75.42	**997.02**	**498.5**	**753.83**	**376.9**
	77	1698.82	150.84	1849.66	924.8	933.19	75.42	**1008.61**	**504.3**	**763.30**	**381.7**
	78	1719.54	150.84	1870.38	935.2	944.58	75.42	**1020.00**	**510.0**	**772.63**	**386.3**
	79	1739.94	150.84	1890.78	945.4	955.80	75.42	**1031.22**	**515.6**	**781.81**	**390.9**
	80	1759.98	150.84	1910.82	955.4	966.82	75.42	**1042.24**	**521.1**	**790.83**	**395.4**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
42-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Below Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	R_n Total Nominal Geotechnical Axial Resistance (tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**ϕR_n Total Factored Geotechnical Axial Resistance (tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (tons)**
	1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	3	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	4	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	5	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	6	4.54	65.08	69.60	34.8	2.04	26.03	**28.08**	**14.0**	**1.59**	**0.8**
	7	9.08	69.74	78.82	39.4	4.09	27.90	**31.98**	**16.0**	**3.18**	**1.6**
Clay	8	13.60	75.60	89.22	44.6	6.12	30.24	**36.36**	**18.2**	**4.76**	**2.4**
Sand	9	27.44	81.46	108.90	54.5	13.73	40.73	**54.46**	**27.2**	**10.99**	**5.5**
	10	42.44	87.34	129.78	64.9	21.98	43.67	**65.65**	**32.8**	**17.74**	**8.9**
	11	58.60	93.20	151.80	75.9	30.87	46.60	**77.47**	**38.7**	**25.01**	**12.5**
	12	75.86	99.06	174.92	87.5	40.36	49.53	**89.89**	**44.9**	**32.78**	**16.4**
	13	94.18	104.94	199.10	99.6	50.44	52.47	**102.91**	**51.5**	**41.02**	**20.5**
	14	113.52	110.80	224.32	112.2	61.08	55.40	**116.48**	**58.2**	**49.72**	**24.9**
	15	133.84	116.66	250.52	125.3	72.25	58.33	**130.58**	**65.3**	**58.87**	**29.4**
	16	155.12	122.52	277.66	138.8	83.96	61.26	**145.22**	**72.6**	**68.44**	**34.2**
	17	177.34	128.40	305.72	152.9	96.18	64.20	**160.38**	**80.2**	**78.44**	**39.2**
	18	200.42	134.26	334.68	167.3	108.87	67.13	**176.00**	**88.0**	**88.83**	**44.4**
	19	224.36	140.12	364.48	182.2	122.04	70.06	**192.10**	**96.0**	**99.60**	**49.8**
	20	249.12	146.00	395.10	197.6	135.66	73.00	**208.66**	**104.3**	**110.74**	**55.4**
	21	274.66	151.86	426.52	213.3	149.70	75.93	**225.63**	**112.8**	**122.24**	**61.1**
	22	300.98	157.72	458.70	229.4	164.18	78.86	**243.04**	**121.5**	**134.08**	**67.0**
	23	328.00	163.60	491.60	245.8	179.04	81.80	**260.84**	**130.4**	**146.24**	**73.1**
	24	355.76	169.46	525.20	262.6	194.31	84.73	**279.04**	**139.5**	**158.73**	**79.4**
	25	384.16	175.32	559.48	279.7	209.93	87.66	**297.59**	**148.8**	**171.51**	**85.8**
	26	413.22	181.18	594.42	297.2	225.91	90.59	**316.50**	**158.3**	**184.59**	**92.3**
	27	442.90	187.06	629.96	315.0	242.24	93.53	**335.77**	**167.9**	**197.95**	**99.0**
	28	473.18	192.92	666.10	333.1	258.89	96.46	**355.35**	**177.7**	**211.57**	**105.8**
	29	504.02	197.74	701.76	350.9	275.85	98.87	**374.72**	**187.4**	**225.45**	**112.7**
	30	535.40	201.40	736.80	368.4	293.11	100.70	**393.81**	**196.9**	**239.57**	**119.8**
	31	567.30	203.74	771.04	385.5	310.66	101.87	**412.53**	**206.3**	**253.93**	**127.0**
	32	599.70	204.92	804.60	402.3	328.48	102.46	**430.94**	**215.5**	**268.51**	**134.3**
	33	632.54	205.30	837.86	418.9	346.54	102.65	**449.19**	**224.6**	**283.28**	**141.6**
	34	665.84	205.30	871.16	435.6	364.85	102.65	**467.50**	**233.8**	**298.27**	**149.1**
	35	699.56	205.30	904.86	452.4	383.40	102.65	**486.05**	**243.0**	**313.44**	**156.7**
	36	733.68	205.30	938.98	469.5	402.16	102.65	**504.81**	**252.4**	**328.80**	**164.4**
@ 37.2'	37	768.18	205.30	973.48	486.7	421.14	102.65	**523.79**	**261.9**	**344.32**	**172.2**
	38	802.56	205.30	1007.86	503.9	440.05	102.65	**542.70**	**271.3**	**359.79**	**179.9**
	39	836.82	205.30	1042.12	521.1	458.89	102.65	**561.54**	**280.8**	**375.21**	**187.6**
	40	870.96	205.30	1076.26	538.1	477.67	102.65	**580.32**	**290.2**	**390.57**	**195.3**

Drilled Shaft Capacities
Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5
42-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Below Pile Cap	Nominal Side Resistance	Nominal End Bearing	R_n Total Nominal Geotechnical Axial Resistance		Factored Nominal Side Resistance	Factored Nominal End Bearing	**ϕR_n Total Factored Geotechnical Axial Resistance**		**ϕR_n Total Factored Geotechnical Uplift Resistance**	
	(ft)	(kips)	(kips)	(kips)	(tons)	(kips)	(kips)	**(kips)**	**(tons)**	**(kips)**	**(tons)**
Sand	41	904.98	205.30	1110.28	555.1	496.38	102.65	**599.03**	**299.5**	**405.88**	**202.9**
	42	938.86	205.30	1144.16	572.1	515.01	102.65	**617.66**	**308.8**	**421.13**	**210.6**
	43	972.58	205.30	1177.88	588.9	533.56	102.65	**636.21**	**318.1**	**436.30**	**218.2**
	44	1006.16	205.30	1211.46	605.7	552.03	102.65	**654.68**	**327.3**	**451.41**	**225.7**
	45	1039.58	205.30	1244.88	622.4	570.41	102.65	**673.06**	**336.5**	**466.45**	**233.2**
	46	1072.84	205.30	1278.14	639.1	588.70	102.65	**691.35**	**345.7**	**481.42**	**240.7**
	47	1105.92	205.30	1311.22	655.6	606.90	102.65	**709.55**	**354.8**	**496.30**	**248.2**
	48	1138.82	205.30	1344.12	672.1	624.99	102.65	**727.64**	**363.8**	**511.11**	**255.6**
	49	1171.52	205.30	1376.82	688.4	642.98	102.65	**745.63**	**372.8**	**525.82**	**262.9**
	50	1204.04	205.30	1409.34	704.7	660.86	102.65	**763.51**	**381.8**	**540.46**	**270.2**
	51	1236.34	205.30	1441.64	720.8	678.63	102.65	**781.28**	**390.6**	**554.99**	**277.5**
	52	1268.44	205.30	1473.74	736.9	696.28	102.65	**798.93**	**399.5**	**569.44**	**284.7**
	53	1300.32	205.30	1505.62	752.8	713.82	102.65	**816.47**	**408.2**	**583.78**	**291.9**
	54	1331.98	205.30	1537.28	768.6	731.23	102.65	**833.88**	**416.9**	**598.03**	**299.0**
	55	1363.40	205.30	1568.70	784.4	748.51	102.65	**851.16**	**425.6**	**612.17**	**306.1**
	56	1394.60	205.30	1599.90	800.0	765.67	102.65	**868.32**	**434.2**	**626.21**	**313.1**
	57	1425.54	205.30	1630.84	815.4	782.69	102.65	**885.34**	**442.7**	**640.13**	**320.1**
	58	1456.22	205.30	1661.52	830.8	799.56	102.65	**902.21**	**451.1**	**653.94**	**327.0**
	59	1486.64	205.30	1691.94	846.0	816.29	102.65	**918.94**	**459.5**	**667.63**	**333.8**
	60	1516.80	205.30	1722.10	861.1	832.88	102.65	**935.53**	**467.8**	**681.20**	**340.6**
	61	1546.68	205.30	1752.00	876.0	849.31	102.65	**951.96**	**476.0**	**694.65**	**347.3**
	62	1576.30	205.30	1781.60	890.8	865.61	102.65	**968.26**	**484.1**	**707.98**	**354.0**
	63	1605.60	205.30	1810.92	905.5	881.72	102.65	**984.37**	**492.2**	**721.16**	**360.6**
	64	1634.62	205.30	1839.94	920.0	897.68	102.65	**1000.33**	**500.2**	**734.22**	**367.1**
	65	1663.34	205.30	1868.66	934.3	913.48	102.65	**1016.13**	**508.1**	**747.14**	**373.6**
	66	1691.76	205.30	1897.06	948.5	929.11	102.65	**1031.76**	**515.9**	**759.93**	**380.0**
	67	1719.86	205.30	1925.16	962.6	944.56	102.65	**1047.21**	**523.6**	**772.58**	**386.3**
	68	1747.62	205.30	1952.92	976.5	959.83	102.65	**1062.48**	**531.2**	**785.07**	**392.5**
	69	1775.06	205.30	1980.36	990.2	974.92	102.65	**1077.57**	**538.8**	**797.42**	**398.7**
	70	1802.18	205.30	2007.48	1003.7	989.84	102.65	**1092.49**	**546.2**	**809.62**	**404.8**
	71	1828.94	205.30	2034.24	1017.1	1004.56	102.65	**1107.21**	**553.6**	**821.66**	**410.8**
	72	1855.36	205.30	2060.66	1030.3	1019.09	102.65	**1121.74**	**560.9**	**833.55**	**416.8**
	73	1881.42	205.30	2086.72	1043.4	1033.42	102.65	**1136.07**	**568.0**	**845.28**	**422.6**
	74	1907.10	205.30	2112.42	1056.2	1047.55	102.65	**1150.20**	**575.1**	**856.84**	**428.4**
	75	1932.44	205.30	2137.74	1068.9	1061.48	102.65	**1164.13**	**582.1**	**868.24**	**434.1**
	76	1957.38	205.30	2162.68	1081.3	1075.20	102.65	**1177.85**	**588.9**	**879.46**	**439.7**
	77	1981.96	205.30	2187.26	1093.6	1088.72	102.65	**1191.37**	**595.7**	**890.52**	**445.3**
	78	2006.14	205.30	2211.44	1105.7	1102.02	102.65	**1204.67**	**602.3**	**901.40**	**450.7**
	79	2029.92	205.30	2235.22	1117.6	1115.10	102.65	**1217.75**	**608.9**	**912.10**	**456.1**
	80	2053.30	205.30	2258.60	1129.3	1127.96	102.65	**1230.61**	**615.3**	**922.63**	**461.3**

Drilled Shaft Capacities

Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5

48-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft

Water table at normal pool = 420.0 ft

	Depth Below Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	R_n Total Nominal Geotechnical Axial Resistance (tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**ϕR_n Total Factored Geotechnical Axial Resistance (tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (tons)**
	1	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	2	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	3	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	4	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	5	0.00	0.00	0.00	0.0	0.00	0.00	**0.00**	**0.0**	**0.00**	**0.0**
	6	5.18	78.44	83.62	41.8	2.33	31.38	**33.71**	**16.9**	**1.81**	**0.9**
	7	10.36	83.58	93.94	47.0	4.66	33.43	**38.09**	**19.0**	**3.63**	**1.8**
Clay	8	15.56	90.28	105.84	52.9	7.00	36.11	**43.11**	**21.6**	**5.45**	**2.7**
Sand	9	31.36	96.98	128.34	64.2	15.69	48.49	**64.18**	**32.1**	**12.56**	**6.3**
	10	48.50	103.68	152.18	76.1	25.12	51.84	**76.96**	**38.5**	**20.27**	**10.1**
	11	66.96	110.38	177.34	88.7	35.27	55.19	**90.46**	**45.2**	**28.58**	**14.3**
	12	86.68	117.10	203.78	101.9	46.12	58.55	**104.67**	**52.3**	**37.45**	**18.7**
	13	107.62	123.80	231.42	115.7	57.64	61.90	**119.54**	**59.8**	**46.87**	**23.4**
	14	129.74	130.50	260.24	130.1	69.80	65.25	**135.05**	**67.5**	**56.83**	**28.4**
	15	152.96	137.20	290.16	145.1	82.57	68.60	**151.17**	**75.6**	**67.28**	**33.6**
	16	177.30	143.90	321.20	160.6	95.96	71.95	**167.91**	**84.0**	**78.23**	**39.1**
	17	202.66	150.62	353.28	176.6	109.91	75.31	**185.22**	**92.6**	**89.64**	**44.8**
	18	229.04	157.32	386.36	193.2	124.42	78.66	**203.08**	**101.5**	**101.51**	**50.8**
	19	256.40	164.02	420.42	210.2	139.46	82.01	**221.47**	**110.7**	**113.82**	**56.9**
	20	284.70	170.72	455.42	227.7	155.03	85.36	**240.39**	**120.2**	**126.56**	**63.3**
	21	313.90	177.42	491.32	245.7	171.09	88.71	**259.80**	**129.9**	**139.70**	**69.8**
	22	343.96	184.14	528.10	264.1	187.62	92.07	**279.69**	**139.8**	**153.23**	**76.6**
	23	374.86	190.84	565.70	282.9	204.62	95.42	**300.04**	**150.0**	**167.13**	**83.6**
	24	406.58	197.54	604.12	302.1	222.06	98.77	**320.83**	**160.4**	**181.41**	**90.7**
	25	439.04	204.24	643.28	321.6	239.92	102.12	**342.04**	**171.0**	**196.01**	**98.0**
	26	472.26	210.94	683.20	341.6	258.19	105.47	**363.66**	**181.8**	**210.96**	**105.5**
	27	506.18	217.64	723.82	361.9	276.84	108.82	**385.66**	**192.8**	**226.23**	**113.1**
	28	540.78	224.36	765.14	382.6	295.87	112.18	**408.05**	**204.0**	**241.80**	**120.9**
	29	576.02	231.06	807.08	403.5	315.26	115.53	**430.79**	**215.4**	**257.65**	**128.8**
	30	611.90	237.76	849.66	424.8	334.99	118.88	**453.87**	**226.9**	**273.80**	**136.9**
	31	648.34	244.46	892.80	446.4	355.03	122.23	**477.26**	**238.6**	**290.20**	**145.1**
	32	685.36	251.16	936.52	468.3	375.39	125.58	**500.97**	**250.5**	**306.86**	**153.4**
	33	722.92	256.86	979.78	489.9	396.05	128.43	**524.48**	**262.2**	**323.76**	**161.9**
	34	760.96	261.44	1022.40	511.2	416.97	130.72	**547.69**	**273.8**	**340.88**	**170.4**
	35	799.50	264.80	1064.30	532.2	438.17	132.40	**570.57**	**285.3**	**358.22**	**179.1**
	36	838.50	266.80	1105.30	552.7	459.62	133.40	**593.02**	**296.5**	**375.77**	**187.9**
@ 37.2'	37	877.90	267.82	1145.72	572.9	481.29	133.91	**615.20**	**307.6**	**393.50**	**196.7**
	38	917.20	268.16	1185.36	592.7	502.90	134.08	**636.98**	**318.5**	**411.18**	**205.6**
	39	956.36	268.16	1224.52	612.3	524.44	134.08	**658.52**	**329.3**	**428.81**	**214.4**
	40	995.38	268.16	1263.54	631.8	545.90	134.08	**679.98**	**340.0**	**446.37**	**223.2**

Drilled Shaft Capacities

Kennedy Interchanges S0620 (BA-1) Bridge, Piers 1 to 5

48-inch Diameter Shaft

Estimated Base of Pile Cap Elevation = 457.2 ft

Water table at normal pool = 420.0 ft

	Depth Below Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	R_n Total Nominal Geotechnical Axial Resistance (kips)	(tons)	Factored Nominal Side Resistance (kips)	Factored Nominal End Bearing (kips)	**ϕR_n Total Factored Geotechnical Axial Resistance (kips)**	**(tons)**	**ϕR_n Total Factored Geotechnical Uplift Resistance (kips)**	**(tons)**
Sand	41	1034.26	268.16	1302.42	651.2	567.29	134.08	**701.37**	**350.7**	**463.86**	**231.9**
	42	1072.98	268.16	1341.14	670.6	588.58	134.08	**722.66**	**361.3**	**481.29**	**240.6**
	43	1111.52	268.16	1379.68	689.8	609.78	134.08	**743.86**	**371.9**	**498.63**	**249.3**
	44	1149.90	268.16	1418.06	709.0	630.89	134.08	**764.97**	**382.5**	**515.90**	**257.9**
	45	1188.10	268.16	1456.26	728.1	651.90	134.08	**785.98**	**393.0**	**533.09**	**266.5**
	46	1226.10	268.16	1494.26	747.1	672.80	134.08	**806.88**	**403.4**	**550.19**	**275.1**
	47	1263.90	268.16	1532.06	766.0	693.59	134.08	**827.67**	**413.8**	**567.20**	**283.6**
	48	1301.50	268.16	1569.66	784.8	714.27	134.08	**848.35**	**424.2**	**584.12**	**292.1**
	49	1338.88	268.16	1607.04	803.5	734.83	134.08	**868.91**	**434.5**	**600.94**	**300.5**
	50	1376.04	268.16	1644.20	822.1	755.27	134.08	**889.35**	**444.7**	**617.66**	**308.8**
	51	1412.96	268.16	1681.12	840.6	775.57	134.08	**909.65**	**454.8**	**634.28**	**317.1**
	52	1449.64	268.16	1717.80	858.9	795.75	134.08	**929.83**	**464.9**	**650.78**	**325.4**
	53	1486.08	268.16	1754.24	877.1	815.79	134.08	**949.87**	**474.9**	**667.18**	**333.6**
	54	1522.26	268.16	1790.42	895.2	835.69	134.08	**969.77**	**484.9**	**683.46**	**341.7**
	55	1558.18	268.16	1826.34	913.2	855.44	134.08	**989.52**	**494.8**	**699.63**	**349.8**
	56	1593.82	268.16	1861.98	931.0	875.05	134.08	**1009.13**	**504.6**	**715.66**	**357.8**
	57	1629.18	268.16	1897.34	948.7	894.49	134.08	**1028.57**	**514.3**	**731.58**	**365.8**
	58	1664.26	268.16	1932.42	966.2	913.79	134.08	**1047.87**	**523.9**	**747.36**	**373.7**
	59	1699.02	268.16	1967.18	983.6	932.91	134.08	**1066.99**	**533.5**	**763.00**	**381.5**
	60	1733.50	268.16	2001.66	1000.8	951.87	134.08	**1085.95**	**543.0**	**778.52**	**389.3**
	61	1767.64	268.16	2035.80	1017.9	970.65	134.08	**1104.73**	**552.4**	**793.88**	**396.9**
	62	1801.48	268.16	2069.64	1034.8	989.26	134.08	**1123.34**	**561.7**	**809.11**	**404.6**
	63	1834.98	268.16	2103.14	1051.6	1007.68	134.08	**1141.76**	**570.9**	**824.19**	**412.1**
	64	1868.14	268.16	2136.30	1068.2	1025.92	134.08	**1160.00**	**580.0**	**839.11**	**419.6**
	65	1900.96	268.16	2169.12	1084.6	1043.97	134.08	**1178.05**	**589.0**	**853.88**	**426.9**
	66	1933.44	268.16	2201.60	1100.8	1061.84	134.08	**1195.92**	**598.0**	**868.49**	**434.2**
	67	1965.54	268.16	2233.70	1116.9	1079.49	134.08	**1213.57**	**606.8**	**882.94**	**441.5**
	68	1997.28	268.16	2265.44	1132.7	1096.95	134.08	**1231.03**	**615.5**	**897.22**	**448.6**
	69	2028.64	268.16	2296.80	1148.4	1114.20	134.08	**1248.28**	**624.1**	**911.33**	**455.7**
	70	2059.62	268.16	2327.78	1163.9	1131.24	134.08	**1265.32**	**632.7**	**925.27**	**462.6**
	71	2090.22	268.16	2358.38	1179.2	1148.07	134.08	**1282.15**	**641.1**	**939.04**	**469.5**
	72	2120.40	268.16	2388.56	1194.3	1164.66	134.08	**1298.74**	**649.4**	**952.62**	**476.3**
	73	2150.18	268.16	2418.34	1209.2	1181.04	134.08	**1315.12**	**657.6**	**966.03**	**483.0**
	74	2179.56	268.16	2447.72	1223.9	1197.20	134.08	**1331.28**	**665.6**	**979.25**	**489.6**
	75	2208.50	268.16	2476.66	1238.3	1213.12	134.08	**1347.20**	**673.6**	**992.27**	**496.1**
	76	2237.02	268.16	2505.18	1252.6	1228.81	134.08	**1362.89**	**681.4**	**1005.10**	**502.6**
	77	2265.10	268.16	2533.26	1266.6	1244.25	134.08	**1378.33**	**689.2**	**1017.74**	**508.9**
	78	2292.72	268.16	2560.88	1280.4	1259.44	134.08	**1393.52**	**696.8**	**1030.17**	**515.1**
	79	2319.90	268.16	2588.06	1294.0	1274.39	134.08	**1408.47**	**704.2**	**1042.40**	**521.2**
	80	2346.64	268.16	2614.80	1307.4	1289.10	134.08	**1423.18**	**711.6**	**1054.43**	**527.2**

Appendix I

H-Pile Driving Resistances

H-Pile Driving Resistance

Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2, Piers 1 to 5

12x53 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	H-Pile Driving Resistance	
	(ft)	(kips)	(kips)	(kips)	(tons)
	1	2.47	0.73	1.97	1.0
	2	4.94	0.73	3.20	1.6
	3	7.42	0.73	4.44	2.2
	4	9.89	0.73	5.67	2.8
	5	12.36	0.73	6.91	3.5
	6	14.83	0.73	8.15	4.1
	7	17.30	0.73	9.38	4.7
	8	19.78	0.73	10.62	5.3
Clay	8.4	20.77	0.73	11.11	5.6
Sand	8.4	15.45	6.76	13.16	6.6
	9	23.03	7.91	19.99	10.0
Contributes to Downdrag	10	26.84	7.91	22.85	11.4
	11	30.64	7.91	25.70	12.8
	12	34.44	7.91	28.55	14.3
	13	38.25	7.91	31.40	15.7
	14	42.05	7.91	34.26	17.1
	15	45.85	7.91	37.11	18.6
	16	49.66	7.91	39.96	20.0
	17	53.46	7.91	42.81	21.4
	18	58.37	7.91	46.50	23.2
	19	64.05	7.91	50.76	25.4
	20	69.73	7.91	55.01	27.5
	21	75.41	7.91	59.27	29.6
	22	81.09	7.91	63.53	31.8
	23	86.76	7.91	67.79	33.9
	24	92.44	7.91	72.05	36.0
	25	98.12	7.91	76.31	38.2
	26	103.80	7.91	80.57	40.3
	27	110.59	7.91	85.66	42.8
	28	118.14	7.91	91.32	45.7
	29	125.70	7.91	96.99	48.5
	30	133.25	7.91	102.66	51.3
	31	140.80	7.91	108.32	54.2
	31.6	145.34	7.91	111.72	55.9
	32	148.36	7.91	113.99	57.0
	33	155.91	7.91	119.65	59.8
	34	163.47	7.91	125.32	62.7
	35	171.02	7.91	130.99	65.5
	36	179.24	7.91	137.15	68.6
	37	187.92	7.91	143.66	71.8
@ 37.2'	38	197.12	7.91	150.56	75.3
	39	206.46	7.91	157.56	78.8
	40	215.79	7.91	164.56	82.3

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	Total Driving Resistance	
	(ft)	(kips)	(kips)	(kips)	(tons)
Sand	41	225.12	7.91	171.56	85.8
	42	234.46	7.91	178.56	89.3
	43	243.79	7.91	185.56	92.8
	44	253.12	7.91	192.56	96.3
	45	262.46	7.91	199.56	99.8
	46	271.79	7.91	206.56	103.3
	47	281.86	7.91	214.11	107.1
	48	292.13	7.91	221.81	110.9
	49	302.39	7.91	229.51	114.8
	50	312.66	7.91	237.21	118.6
	51	322.93	7.91	244.91	122.5
	52	333.19	7.91	252.61	126.3
	53	343.46	7.91	260.31	130.2
	54	353.73	7.91	268.01	134.0
	55	363.99	7.91	275.71	137.9
	56	375.00	7.91	283.97	142.0
	57	386.19	7.91	292.36	146.2
	58	397.39	7.91	300.76	150.4
	59	408.59	7.91	309.16	154.6
	60	419.79	7.91	317.56	158.8
	61	430.99	7.91	325.96	163.0
	62	442.18	7.91	334.36	167.2
	63	453.38	7.91	342.75	171.4
	64	464.58	7.91	351.15	175.6
	65	476.51	7.91	360.10	180.1
	66	488.64	7.91	369.20	184.6
	67	500.77	7.91	378.30	189.1
	68	512.90	7.91	387.40	193.7
	69	525.03	7.91	396.49	198.2
	70	537.16	7.91	405.59	202.8
	71	549.29	7.91	414.69	207.3
	72	561.42	7.91	423.79	211.9
	73	573.55	7.91	432.88	216.4
	74	586.42	7.91	442.53	221.3
	75	599.48	7.91	452.33	226.2
	76	612.54	7.91	462.13	231.1
	77	625.61	7.91	471.92	236.0
	78	638.67	7.91	481.72	240.9
	79	651.73	7.91	491.52	245.8
	80	664.79	7.91	501.31	250.7

* Refer to capacity tables and/or construction drawings for required depth/capacities that incorporate other loads that have been accounted for in the design of these piles.

H-Pile Driving Resistance

Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2, Piers 1 to 5

14x73 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft
Water table at normal pool = 420.0 ft

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	H-Pile Driving Resistance (kips)	H-Pile Driving Resistance (tons)
	1	2.92	1.00	2.46	1.2
	2	5.85	1.00	3.92	2.0
	3	8.77	1.00	5.39	2.7
	4	11.70	1.00	6.85	3.4
	5	14.62	1.00	8.31	4.2
	6	17.55	1.00	9.77	4.9
	7	20.47	1.00	11.24	5.6
	8	23.40	1.00	12.70	6.3
Clay	8.4	24.58	1.00	13.29	6.6
Sand	8.4	18.28	9.33	16.90	8.4
	9	27.64	10.93	25.52	12.8
Contributes to Downdrag	10	32.78	10.93	29.37	14.7
	11	37.93	10.93	33.23	16.6
	12	43.07	10.93	37.09	18.5
	13	48.21	10.93	40.94	20.5
	14	53.35	10.93	44.80	22.4
	15	58.49	10.93	48.65	24.3
	16	63.63	10.93	52.51	26.3
	17	68.77	10.93	56.37	28.2
	18	75.41	10.93	61.34	30.7
	19	83.09	10.93	67.10	33.6
	20	90.76	10.93	72.86	36.4
	21	98.44	10.93	78.62	39.3
	22	106.12	10.93	84.37	42.2
	23	113.79	10.93	90.13	45.1
	24	121.47	10.93	95.89	47.9
	25	129.15	10.93	101.65	50.8
	26	136.82	10.93	107.40	53.7
	27	146.00	10.93	114.28	57.1
	28	156.21	10.93	121.94	61.0
	29	166.43	10.93	129.61	64.8
	30	176.64	10.93	137.27	68.6
	31	186.85	10.93	144.93	72.5
	32	197.07	10.93	152.59	76.3
	32.3	200.13	10.93	154.88	77.4
	33	207.28	10.93	160.25	80.1
	34	217.50	10.93	167.91	84.0
	35	227.71	10.93	175.57	87.8
	36	238.82	10.93	183.90	92.0
	37	250.55	10.93	192.70	96.3
@ 37.2'	38	262.99	10.93	202.03	101.0
	39	275.61	10.93	211.49	105.7
	40	288.23	10.93	220.96	110.5

	Depth Pile Cap (ft)	Nominal Side Resistance (kips)	Nominal End Bearing (kips)	Total Driving Resistance (kips)	Total Driving Resistance (tons)
Sand	41	300.85	10.93	230.42	115.2
	42	313.46	10.93	239.88	119.9
	43	326.08	10.93	249.35	124.7
	44	338.70	10.93	258.81	129.4
	45	351.32	10.93	268.28	134.1
	46	363.94	10.93	277.74	138.9
	47	377.55	10.93	287.95	144.0
	48	391.43	10.93	298.36	149.2
	49	405.31	10.93	308.77	154.4
	50	419.19	10.93	319.18	159.6
	51	433.06	10.93	329.58	164.8
	52	446.94	10.93	339.99	170.0
	53	460.82	10.93	350.40	175.2
	54	474.70	10.93	360.81	180.4
	55	488.58	10.93	371.22	185.6
	56	503.45	10.93	382.37	191.2
	57	518.59	10.93	393.73	196.9
	58	533.73	10.93	405.08	202.5
	59	548.87	10.93	416.44	208.2
	60	564.01	10.93	427.79	213.9
	61	579.14	10.93	439.14	219.6
	62	594.28	10.93	450.50	225.2
	63	609.42	10.93	461.85	230.9
	64	624.56	10.93	473.21	236.6
	65	640.69	10.93	485.31	242.7
	66	657.09	10.93	497.61	248.8
	67	673.49	10.93	509.90	255.0
	68	689.89	10.93	522.20	261.1
	69	706.29	10.93	534.50	267.3
	70	722.68	10.93	546.80	273.4
	71	739.08	10.93	559.10	279.5
	72	755.48	10.93	571.40	285.7
	73	771.88	10.93	583.69	291.8
	74	789.27	10.93	596.74	298.4
	75	806.93	10.93	609.98	305.0
	76	824.59	10.93	623.23	311.6
	77	842.25	10.93	636.47	318.2
	78	859.91	10.93	649.72	324.9
	79	877.56	10.93	662.96	331.5
	80	895.22	10.93	676.20	338.1

* Refer to capacity tables and/or construction drawings for required depth/capacities that incorporate other loads that have been accounted for in the design of these piles.

H-Pile Driving Resistance

Kennedy Interchanges S0620 (BA-1) Bridge, Abutments 1 and 2, Piers 1 to 5

14x89 H-Pile (50ksi steel)

Estimated Base of Pile Cap Elevation = 457.2 ft

Water table at normal pool = 420.0 ft

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	H-Pile Driving Resistance	
	(ft)	(kips)	(kips)	(kips)	(tons)
	1	2.96	1.22	2.70	1.3
	2	5.92	1.22	4.18	2.1
	3	8.88	1.22	5.66	2.8
	4	11.83	1.22	7.14	3.6
	5	14.79	1.22	8.62	4.3
	6	17.75	1.22	10.10	5.0
	7	20.72	1.22	11.58	5.8
	8	23.68	1.22	13.06	6.5
Clay	8.4	24.87	1.22	13.65	6.8
Sand	8.4	24.87	11.38	23.81	11.9
	9	28.24	13.33	28.30	14.1
	10	33.91	13.33	32.54	16.3
	11	39.57	13.33	36.79	18.4
	12	45.24	13.33	41.04	20.5
Contributes to Downdrag	13	50.90	13.33	45.29	22.6
	14	56.57	13.33	49.54	24.8
	15	62.24	13.33	53.79	26.9
	16	67.90	13.33	58.04	29.0
	17	73.57	13.33	62.29	31.1
	18	80.88	13.33	67.78	33.9
	19	89.34	13.33	74.12	37.1
	20	97.80	13.33	80.47	40.2
	21	106.27	13.33	86.81	43.4
	22	114.73	13.33	93.16	46.6
	23	123.19	13.33	99.50	49.8
	24	131.65	13.33	105.85	52.9
	25	140.11	13.33	112.20	56.1
	26	148.57	13.33	118.54	59.3
	27	158.68	13.33	126.12	63.1
	28	169.94	13.33	134.57	67.3
	29	181.19	13.33	143.01	71.5
	30	192.45	13.33	151.45	75.7
	31	203.71	13.33	159.89	79.9
	32	214.96	13.33	168.34	84.2
	33	226.22	13.33	176.78	88.4
	33.7	234.10	13.33	182.69	91.3
	34	237.48	13.33	185.22	92.6
	35	248.73	13.33	193.66	96.8
	36	260.98	13.33	202.85	101.4
	37	273.91	13.33	212.55	106.3
@ 37.2'	38	287.62	13.33	222.83	111.4
	39	301.52	13.33	233.26	116.6
	40	315.43	13.33	243.69	121.8

	Depth Pile Cap	Nominal Side Resistance	Nominal End Bearing	Total Driving Resistance	
	(ft)	(kips)	(kips)	(kips)	(tons)
Sand	41	329.34	13.33	254.12	127.1
	42	343.24	13.33	264.55	132.3
	43	357.15	13.33	274.98	137.5
	44	371.06	13.33	285.41	142.7
	45	384.96	13.33	295.84	147.9
	46	398.87	13.33	306.27	153.1
	47	413.87	13.33	317.52	158.8
	48	429.17	13.33	328.99	164.5
	49	444.46	13.33	340.46	170.2
	50	459.76	13.33	351.93	176.0
	51	475.06	13.33	363.41	181.7
	52	490.35	13.33	374.88	187.4
	53	505.65	13.33	386.35	193.2
	54	520.94	13.33	397.82	198.9
	55	536.24	13.33	409.29	204.6
	56	552.63	13.33	421.59	210.8
	57	569.32	13.33	434.10	217.1
	58	586.00	13.33	446.61	223.3
	59	602.68	13.33	459.13	229.6
	60	619.37	13.33	471.64	235.8
	61	636.05	13.33	484.15	242.1
	62	652.74	13.33	496.67	248.3
	63	669.42	13.33	509.18	254.6
	64	686.11	13.33	521.69	260.8
	65	703.89	13.33	535.03	267.5
	66	721.96	13.33	548.58	274.3
	67	740.03	13.33	562.14	281.1
	68	758.10	13.33	575.69	287.8
	69	776.18	13.33	589.25	294.6
	70	794.25	13.33	602.80	301.4
	71	812.32	13.33	616.35	308.2
	72	830.39	13.33	629.91	315.0
	73	848.46	13.33	643.46	321.7
	74	867.64	13.33	657.84	328.9
	75	887.10	13.33	672.44	336.2
	76	906.56	13.33	687.03	343.5
	77	926.02	13.33	701.63	350.8
	78	945.48	13.33	716.23	358.1
	79	964.95	13.33	730.82	365.4
	80	984.41	13.33	745.42	372.7

* Refer to capacity tables and/or construction drawings for required depth/capacities that incorporate other loads that have been accounted for in the design of these piles.